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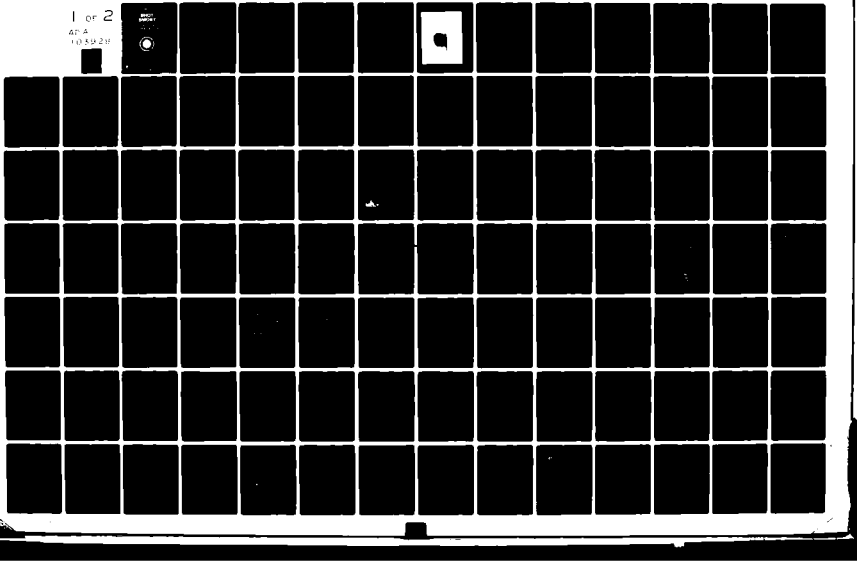

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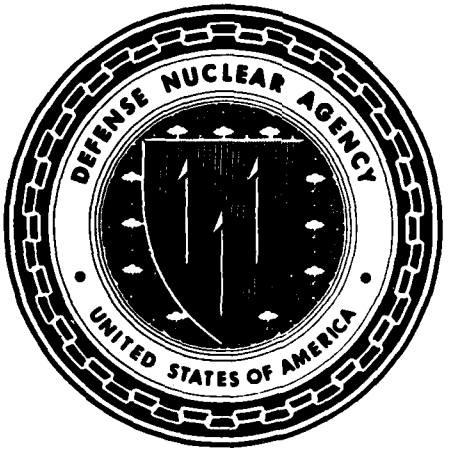
SHOT SMOKY

A Test of the PLUMBBOB Series

31 AUGUST 1957



United States Atmospheric Nuclear Weapons Tests

Nuclear Test Personnel Review

Prepared by the Defense Nuclear Agency as Executive Agency
for the Department of Defense

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SMOKY	Ionizing Radiation	Infantry Troop Test
PLUMBBOB	AEC	AFSWC
GALILEO	AFSWP	Fallout
Task Force WARRIOR	Desert Rock	Decontamination
Radioactivity	Radiation Exposure	Atmospheric Nuclear Tests

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes the activities of DOD participants in the atmospheric nuclear test, SMOKY, conducted on 31 August 1957 as part of the PLUMBBOB series. The various levels at which DOD personnel participated within the Nevada Test Organization and Desert Rock projects are described. Those projects related to DOD mission activities are described as to purpose, agency, results, operation, and radiological safety aspects.

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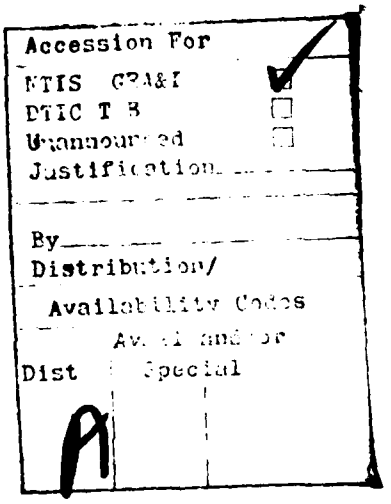

PREFACE

This volume describes the activities of shot SMOKY, an atmospheric nuclear weapon test of the PLUMBBOB series conducted at the Nevada Test Site on 31 August 1957. As a document it is not intended to stand alone, but to be used in conjunction with the overall report of the test series PLUMBBOB.

The larger, more extensive report concerning the PLUMBBOB series describes:

- Historical and political prospectives
- The general geographic, physical, and administrative settings
- Activities of DOD personnel both in the Desert Rock maneuvers and the Nevada Test Organization
- Scientific, diagnostic, technical, and training projects common to all shots in PLUMBBOB
- Overall radiological safety standards directives, precautions, operations, and results
- Statistical analyses of available radiological exposure data for test series participants.

This report is intended to address only the specifics of the SMOKY nuclear test and those aspects unique to the detonation and personnel involved. Particular emphasis has been placed on the radiological environment and an analysis of radiation exposures has been included.

No single, standardized set of linear dimensions is used in this report. While altitudes are generally given in feet, other distances may be in yards, meters, or variations of either. This is because the data is taken from original sources and used exactly as researched. For those who desire to change any distance to another form, the following are conversion factors:

1 foot = 0.3048 meters	1 meter = 3.2808 feet
1 yard = 0.9144 meters	1 meter = 1.0936 yards
1 mile = 1.609 kilometers	1 kilometer = 0.621 miles

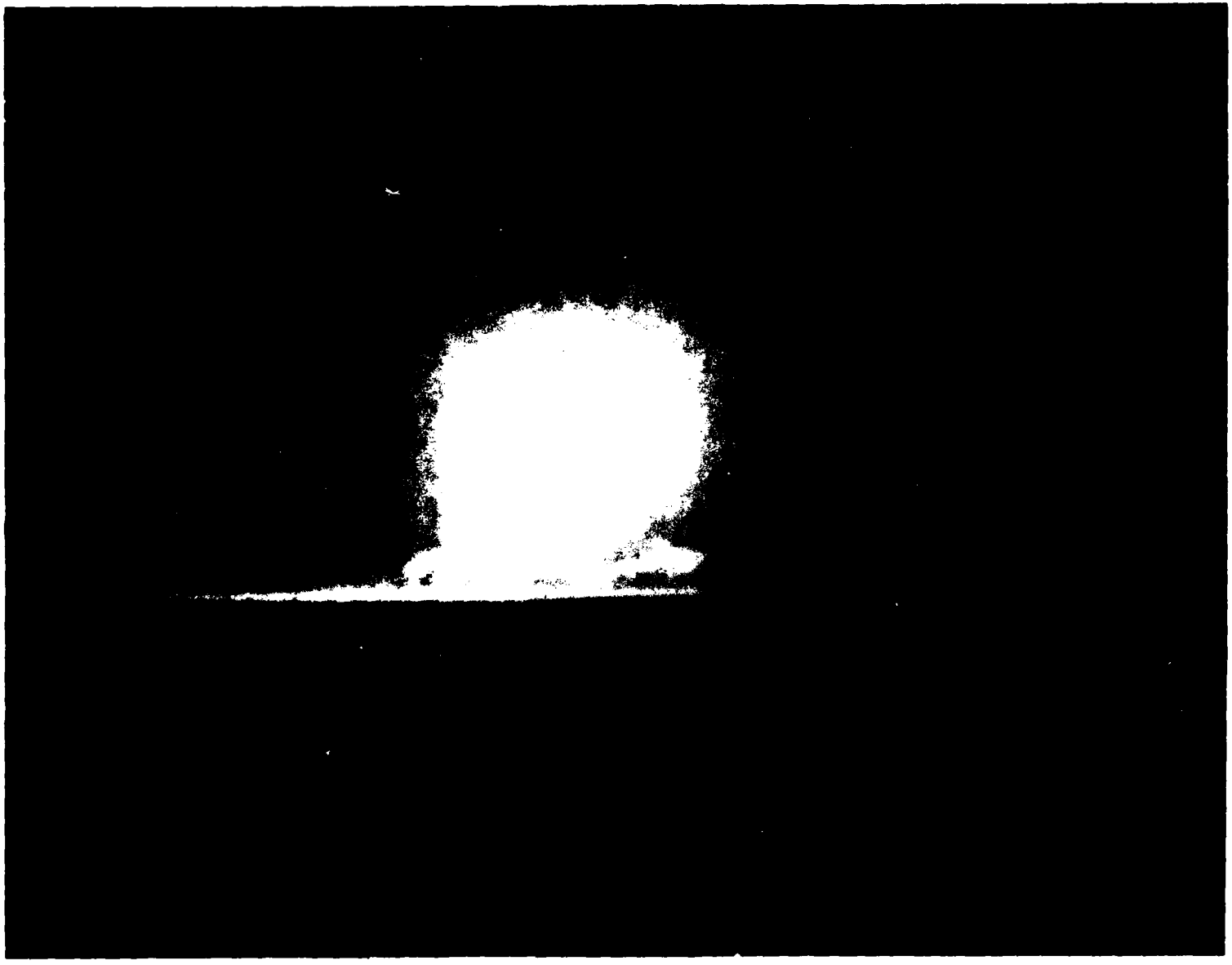

Figure 1. SHOT SMOKY, 31 AUGUST 1957.

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ABBREVIATIONS AND ACRONYMS USED IN THIS VOLUME

ACWL	Army Chemical Warfare Laboratory
AEC	Atomic Energy Commission
AFSWC	Air Force Special Weapons Center
AFSWP	Armed Forces Special Weapons Project
BJY	Buster Jangle Y (junction at continuation of Mercury highway and road to Area 7)
BRL	Ballistic Research Laboratories
CDC	Center for Disease Control, Atlanta, GA
CETG	Civil Effects Test Group
CONUS	Continental United States
DASA	Defense Atomic Support Agency (formerly AFSWP, now DNA)
DBM	Division of Biology and Medicine, AEC
DMA	Division of Military Application, AEC
DNA	Defense Nuclear Agency (originally AFSWP, later DASA)
DOD	Department of Defense
DOE	Department of Energy
D+1	Day after detonation
EDR	Exercise Desert Rock
EG&G	Edgerton, Germeshausen and Grier
FC/AFSWP	Field Command/Armed Forces Special Weapons Project
FCDA	Federal Civil Defense Administration
FCWT	Field Command Weapons Test
GZ	Ground Zero
HumRRO	Human Resources Research Office
H+1	One hour after detonation
JTO	Joint Test Organization
KT	kiloton
LASL	Los Alamos Scientific Laboratory
LZ	Landing Zone
MSL	Mean Sea Level
NAS	National Academy of Sciences
NM	Nautical Miles
NOL	Naval Ordnance Laboratory
NRDL	Navy Radiological Defense Laboratory
NTO	Nevada Test Organization
NTPR	Nuclear Test Personnel Review
NTS	Nevada Test Site
Radex	Radiological exclusion
Rad-safe	Radiological safety
REECo	Reynolds Electrical and Engineering Company
R/h	Roentgens-per-hour
R-hour	Time of commencement of post-shot recovery operatons
RSS	Radiological Safety Support
SAC	Strategic Air Command
UCRL	University of California Radiation Laboratory
VA	Veterans Administration

SMOKY SHOT SYNOPSIS

AEC TEST SERIES:	PLUMBBOB
DOD EXERCISES:	DESERT ROCK VII AND VIII
DATE/TIME:	0530 hours, August 31, 1957
LOCATION:	37° 11'14" N; 116° 04'04" W
YIELD	43.8 ± 2 KT
SITE ELEVATION:	4,479 feet
HEIGHT OF BURST:	700 feet (tower shot)
DOD PARTICIPANTS:	17,000 (est.)

AEC Objectives: Weapons development related to devices scheduled for entry into the DOD stockpile.

DOD Objectives: (1) AFSWP technical experiments related to effects of nuclear weapons on the environment, material, etc.

(2) Desert Rock activities to provide orientation, indoctrinate selected observers, develop and test maneuver procedures, train radiological monitoring personnel, and conduct technical effects tests on military equipment.

Weather at Shot Time: No precipitation, temperature 14° C, relative humidity 31%, pressure 856 mbar, wind calm up to 5,000 ft., from north at 8 mph between 5,000-15,000 ft., from west up to 35 mph at higher elevations.

Radiation Exposure History: All personnel were at least eight miles from GZ; therefore exposure to prompt radiation was negligible. Fallout was relatively heavy southeast of GZ. Troop maneuvers were not in the major fallout pattern.

AEC Participants: Test Manager's Organization, LASL, UCRL, Sandia, Contractors

DOD Participants: AFSWP, AFSWC, Exercise Desert Rock Troops and supporting units (This included an infantry airlanded maneuver conducted by a reinforced infantry company. Helicopter transportation and aerial resupply supported this maneuver.)

CHAPTER 1
INTRODUCTION

Shot SMOKY, the 15th atmospheric nuclear weapons test in the Atomic Energy Commission's Operation PLUMBBOB, was detonated atop a 700-foot steel tower on August 31, 1957, at the Nevada Test Site.* The primary objectives of shot SMOKY were to provide an improved nuclear device and to determine both military and civilian effects.

The three main participating Federal agencies at SMOKY were the AEC, which played the leading role through its two weapons laboratories, Los Alamos Scientific Laboratory (LASL) and University of California Radiation Laboratory, (UCRL); the Federal Civil Defense Administration (FCDA), whose work was performed by the Civil Effects Test Group (CETG); and the Department of Defense (DOD), which was represented for most test programs by the Armed Forces Special Weapons Project (AFSWP). Their participation was as follows:

- The AEC had direct authority to conduct nuclear weapons development tests at the NTS and provided the control staff for detonating SMOKY. The AEC weapons laboratories conducted 16 separate scientific and diagnostic experiments; they were assisted by a few DOD personnel.

- The FCDA measured weapons effects important to the safety of civilians in the United States in the event of nuclear war. Some 23 separate projects were undertaken, but only a limited number of DOD personnel participated in these tests.

- AFSWP, in cooperation with the AEC, measured weapons effects of military importance. AFSWP fielded 10 different projects. It was a DOD organization.

Although the AFSWP projects represented the principal DOD research effort during Operation PLUMBBOB, two other defense agencies were prominent at SMOKY: the Air

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*The Nevada Test Site (NTS) was originally and until 1955 called the Nevada Proving Ground. It covers about 1,350 square miles of the Nevada desert and is located in Nye County, about 65 miles northwest of Las Vegas. The test site was operated by the Atomic Energy Commission (AEC) for the specific purpose of testing nuclear weapons. Functions of the AEC are now within the Department of Energy.

Force Special Weapons Center (AFSWC) and Exercise Desert Rock (EDR). AFSWC personnel flew the radioactive cloud sampling and tracking missions and were responsible for controlling air operations; EDR conducted troop tests to develop tactics for the nuclear battlefield.

1.1 THE SETTING FOR SMOKY*

In the early Saturday hours of 31 August 1957, several thousand men gathered at various observation and control points in the Nevada Test Site.† At 0445 the decision was made to detonate shot SMOKY at 0530 hours. The shot had been delayed three days by weather unfavorable to fallout. The latest meteorological data had been evaluated, advice from participating agencies had been considered, and all factors were deemed favorable. The Nevada Test Site had been secured and cleared of all unauthorized personnel. The nearest personnel were eight miles from the SMOKY test location and security guards manned stations and barricades on access roads to prevent unauthorized entry. Military and civilian observers, who had received training on procedures for observing the detonation, were ready at their respective observation posts. Survey teams were standing by to determine the extent of radioactive contamination as soon after the detonation as possible. Scientific project personnel were prepared to enter test areas and recover experiments. Military troops were ready to embark upon a tactical maneuver subsequent to the shot. (The situation is displayed graphically in Figure 1-1). The center of interest was the tower at the northern edge of the Nevada Test Site where the SMOKY nuclear device would be detonated.

The weeks preceding SMOKY had seen both preparation and delay. Originally planned for 19 August, SMOKY was not ready for firing until August 28, and then had been postponed twice due to weather conditions and the environmental effects of preceding nuclear tests. Even as late as 0445 on 31 August, the shot was postponed from 0500 to 0530 to provide time for collecting the weather data essential to predict fallout and to conduct supporting aircraft operations.

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*The University of California Radiation Laboratory, which provided the nuclear device, chose to name its tests after mountains and mountain ranges.

†General description of the test site is drawn from reference 2. (All sources cited in the text are listed alphabetically by author and numbered in the Reference List, appended to this volume. The number given in the citation in the text is the number of the source document in the Reference List.)

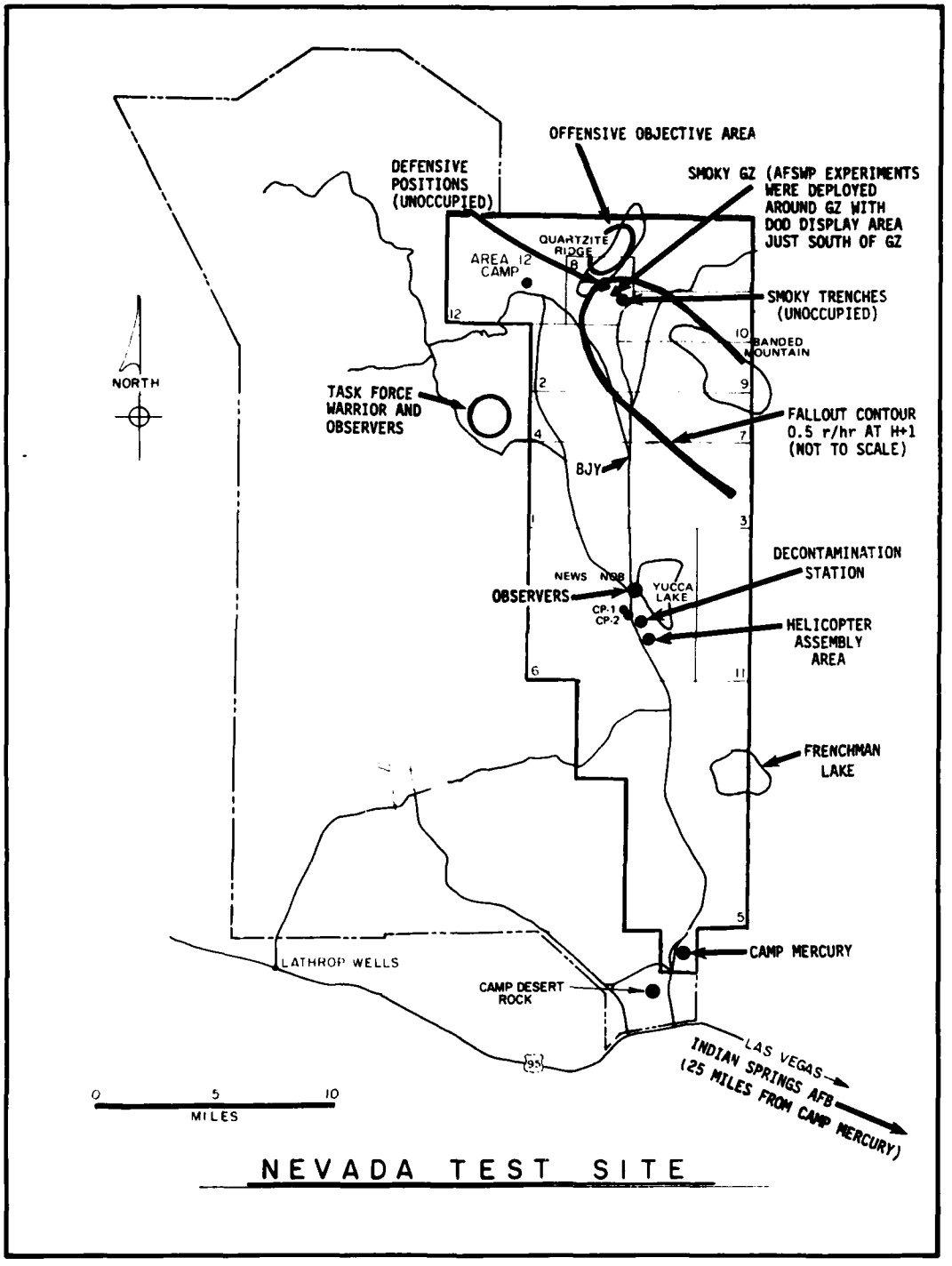

Figure 1-1. NEVADA TEST SITE, SHOWING SMOKY GROUND ZERO.

At the time of the test, approximately 5,800 men occupied two settlements at the Nevada Test Site (Camp Mercury and Camp Desert Rock). An estimated 2,800 men were present at Camp Mercury, a permanent installation located at the southern boundary of the NTS (Area 23), set up by the AEC in 1951 to provide office and living quarters for its temporary and permanent personnel participating in test activities (see Figure 1-1). Personnel at Camp Mercury were responsible for performing the AEC and DOD's Armed Forces Special Weapons Project activities at the Nevada Test Site.

Another 3,000 military men occupied Camp Desert Rock, a temporary encampment which was maintained by a small garrison (9). Sixth Army troops from Camp Irwin, California, reopened and resupplied Camp Desert Rock to accommodate exercise troops during the various weapons tests (see Figure 1-1). Personnel at Camp Desert Rock were responsible for conducting military maneuvers, training, and a few technical projects in an area set aside for them by the AEC Test Manager so as not to interfere with other test activities. In the weeks and hours preceding the detonation, certain of these troops prepared for the maneuvers they would conduct immediately after the shot.

At the shot tower, pre-shot preparations were completed well in advance of the firing. In order to record the effects within the fireball, AFSWP personnel had extended cables from the top of the tower to distant points on the ground; they had also installed ground cables running from the base of the tower like the spokes of a wheel. These cables were instrumented to measure such phenomena as blast effects over uneven terrain and neutron flux during initial radiation. Military equipment and field emplacements were located at varying distances around the tower so that nuclear effects on these items could be studied. In the hours after the detonation, when the levels of radiation permitted, scientific project teams re-entered these areas to retrieve and read the instruments. At test time, however, all areas out to a radius of about eight miles were cleared of personnel.

The shot was to be fired from the control center (CP-1) in Area 6, about 15 miles from the SMOKY tower. The control board in this center could avert the

firing of the device up to the last moment. Even after a weapon was armed and readied for firing, and the automatic sequence for the firing was in progress, the instrumentation at the control board could stop the shot. The control center building (Figure 1-1) had a strategic location, on a rise with a view of Yucca Lake to the north and Frenchman Lake to the south. A landing strip on the dry bed of Yucca Lake made the control center readily accessible by air, and the nearby Mercury highway made it accessible by ground vehicle. In addition, CP-1 provided storage maintenance and supply facilities and was a safe area for operations.

SMOKY was fired at 0530 hours. While the predicted yield for shot SMOKY was 45 kilotons, the output as actually measured was 43.8 kilotons. After the firing, the first step was the radiological safety survey to map contaminated areas around ground zero. Then the scientific and military teams could begin their planned activities. The succeeding portions of this report will specify those agencies present, their goals and responsibilities, and will describe the post-shot activities.

1.2 OVERVIEW OF DEPARTMENT OF DEFENSE PARTICIPATION

DOD was actively involved in two organizations -- the Nevada Test Organization (NTO) and Exercise Desert Rock (EDR) -- which had been set up at the Nevada Test Site to execute the plans for Operation PLUMBBOB.

The Nevada Test Organization was a joint AEC/DOD organization headed by an AEC Test Manager and containing elements of the AEC, DOD/AFSWP, and the FCDA. Functions of the NTO were to fire the planned shots and to perform the scientific weapons-development tests, military effects tests, and civilian tests. DOD personnel were involved at almost every level in the NTO. Military and scientific personnel were assigned to staff activities essential to testing the nuclear device itself and were included in NTO staff offices which coordinated various DOD operations. The AEC, FCDA, and AFSWP technical projects were accomplished by technical groups from various laboratories or organizations, both civilian and military. These technical group activities were coordinated by the Test Director, who was a member of the Test Manager's NTO staff. Other primary support elements included the following:

- The AEC Support Director operated Camp Mercury, the AEC base, and coordinated contractor support activities (such as radiological safety).

- The DOD Support Director was concerned mainly with assistance to AFSWP.

- The Armed Forces Special Weapons Center provided all air support for both AEC and DOD projects at the NTS. In addition, AFSWC flew cloud tracking and sampling missions, security sweeps, and aerial surveys. Finally, AFSWC provided courier and sample return service, and conducted air operational training projects. This group also provided air transport of radioactive samples associated with the tests.

- The DOD Operations Coordination Group was the single point of contact between two major organizations at PLUMBBOB: the NTO and the EDR commander. This group was essential since direct liaison between Exercise Desert Rock and the AEC was not authorized. Activities coordinated by this group included DOD operational training, observer training and indoctrination, technical service projects and Exercise Desert Rock maneuvers.

The second organization, Exercise Desert Rock, was wholly composed of DOD personnel. It contained military units from various parts of the United States stationed at Camp Desert Rock to participate in Desert Rock VII and VIII. The purpose of these exercises was to conduct the Army's planned program of troop training maneuvers, indoctrination, and observation. For the Desert Rock exercises, the overall responsibility for supervising the Army, Navy and Air Force participants belonged to the Desert Rock Exercise Director. The Commanding General, Sixth U.S. Army, was designated to fill this role. His chief aide, the Deputy Exercise Director and Camp Commander of Camp Desert Rock, was directly responsible for conducting the exercises. This position was filled by the Commanding General, Camp Irwin, California.

The Nevada Test Organization and Exercise Desert Rock operated independently of each other for the most part. Exercise Desert Rock operations in the test areas were not to interfere with NTO operations. All Desert Rock operations within the Nevada Test Site were coordinated with the NTO AEC Test Manager through

his Deputy for Military Matters; this latter position was occupied by the Deputy, Chief of Staff, Weapons Effects Tests, AFSWP.

The NTO and EDR had separate but similar radiological safety programs.* The AEC program was in operation at all times. EDR's radiological safety program, however, was primarily in effect during execution of a specified Desert Rock exercise. At other times, Desert Rock personnel in the forward test areas were subject to the procedures established for the NTO program. Both NTO and EDR established procedures to keep exposures of their personnel within the limits shown in Table 1-1.

Table 1-1. RADIOLOGICAL SAFETY CRITERIA (9;28).

AEC		
	Onsite:	3 R/13 weeks--gamma and beta or 5 R/year--gamma and beta 10,000 units per any 13-week period†(alpha)
	Offsite:	3.9 R/13 weeks
DOD		
	AFSWP:	3 R/13 weeks-gamma and beta or 5 R/year-gamma and beta 10,000 units per any 13-week period†(alpha)
	AFSWC:	3 R/13 weeks--gamma and beta or 5 R/year--gamma and beta 10,000 units per any 13-week period†(alpha)
	Desert Rock:	5 R, of which no more than 2 R are prompt or 5 R/6 months§

*AFSWP's and AFSWC's radiological safety procedures were part of the NTO's Rad-safe program. Both the NTO and EDR Rad-safe programs are detailed in the PLUMBBOB series volume.

†A unit is defined as the alpha disintegrations per minute per cubic meter multiplied by the hours of exposure when no protective respiratory equipment is worn.

§Participants normally not at NTS longer than six months.

The Exercise Desert Rock criteria for gamma exposure differed slightly from that of the NTO. For each individual, Desert Rock operations permitted 5 roentgens per test and no more than 5 roentgens per six-month period. This increased exposure was permitted because, unlike the NTO personnel, EDR personnel were not expected to remain more than six months and were not usually engaged in activities where they would be exposed after their short stay at the test site. The limitation did not represent an increase over the NTO limits, but allowed accumulation over a shorter time period to permit greater flexibility in the employment of maneuver forces.

1.3 EXERCISE DESERT ROCK ACTIVITIES

DOD involvement under EDR covered four separate activities: troop tests, troop observer indoctrination programs, training projects, and technical service test projects.

1.3.1 Troop Tests

Two troop tests were planned for SMOKY. First, a U.S. Army Human Resources Research Office (HumRRO) team was to test two aspects of soldiers' performance: their accomplishment of typical military tasks after observing a nuclear detonation, and their probable reactions to operating during nuclear war. Owing to the unfavorable wind conditions, fallout from SMOKY was predicted to contaminate the trench area, and the HumRRO test unit was not deployed. Instead, the test unit (a provisional company from the 82nd Airborne Division) operated during shot GALILEO on 2 September 1957. The other troop test, designated Project 50.1, was an airlanded attack and resupply maneuver. Its initial phase, conducted two weeks prior to the actual firing, included preparation of defensive positions north and west of SMOKY ground zero. These positions were not to be occupied during the test, only to be inspected after the shot. The troops, a reinforced Infantry Company (Task Force WARRIOR), first observed the shot from assembly areas some eight miles from GZ. A Pathfinder unit, trained to enter air assault sites prior to arrival of the main body of troops, flew into the objective area (northwest of the GZ shown on the map, Figure 1-1). It was accompanied by radiological monitors who determined it radiologically safe to enter the objective area. Assault elements were then flown by helicopter to their objectives where the attack began. Helicopter flights continued until all assault elements of the task

force had been brought into the objective area. The exercise was ended at 0945 hours on 31 August 1957 when the assault reached limits established by the radiological safety personnel. Figure 1-1 shows the location for observation, offensive maneuver, and the prepared defensive positions.

1.3.2 Troop Observer Indoctrination Program

The Troop Observer Indoctrination Program provided an orientation for military and civilian personnel. Participants in this program at SMOKY were originally scheduled to observe the shot from trenches located 4,400 yards southeast of GZ (shown in Figure 1-1). However, because weather conditions led to a prediction for heavy fallout on these trenches, the observers watched from the vicinity of News Nob, some 18 miles from GZ.

1.3.3 Radiological Monitoring Training

Exercise Desert Rock operated a radiological monitoring training program in conjunction with shot SMOKY. Personnel from Task Force WARRIOR were trained as monitors as part of this program. Other Exercise Desert Rock radiological safety personnel were also trained in this program and participated in the radiological safety portions of shot SMOKY.

1.3.4 Technical Service Test Projects

During SMOKY, the U.S. Army operated three technical service test projects:

- To examine the capability of current radar equipment to detect the nuclear cloud
- To test fallout prediction methods
- To determine effects of nuclear blast on ordnance equipment placed near the detonation.

1.4 DOD INVOLVEMENT IN NTO ACTIVITIES

The Washington-level authorities responsible for fulfilling the major objectives of Operation PLUMBBOB were the AEC, DOD, and FCDA. Their programs were carried out through the AEC Test Manager's Nevada Test Organization. The AEC Test

Manager, therefore, was charged with actually implementing the objectives of all three sponsoring agencies. This meant, in effect, directing the efforts of the various participating units and ensuring that the job was done safely.

The AEC Test Manager was aided by the Advisory Panel, which helped make the shoot/no shoot decision for this event. Technical advice and information for such decisions were provided by the Test Manager's technical staff and by the Fallout Prediction, Weather Prediction, and Blast Prediction Units. Coordination of the decisions with the test participants was managed through the DOD Operations Coordination Unit, FCDA Operations, and the Air Support Group. Air support for AEC and DOD projects was provided by the 4950th Test Group (Nuclear), a unit under command of the Air Force Special Weapons Center. The 4950th Test Group operated the Air Support Group as part of the AEC Test Manager's Organization. As the focus of all air activity at SMOKY, the 4950th carried out cloud sampling and tracking, in addition to coordinating air operations.* In Chapters 2 and 3, activities for each unit are discussed relative to project or program participation.

The Test Director's organization was a major component of the NTO; it contained the five test groups who conducted the weapons development and other technical programs and who actually prepared and fired the nuclear shots. These were: LASL, UCRL, Sandia, Field Command Weapons Test and CETG. AEC-sponsored work was performed by LASL, UCRL, and Sandia. The extensive DOD-sponsored program on weapons effects (AFSWP programs 1-9) was performed by the Field Command Weapons Test group, supported by the Field Command Support Unit which provided such services as supply, transportation, and communications. FCDA-sponsored work was done by the CETG, whose purpose was to examine weapons effects relative to civil defense.

In addition to these five test groups, three technical support groups under the Test Director provided the necessary scientific support to all test groups:

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*A detailed discussion of the organizational relationships for units under the 4950th Test Group is provided in the PLUMBBOB series volume. These relationships remained in effect during shot SMOKY.

- The EG&G (Edgerton, Germeshausen, and Grier, an AEC contractor) Support Group furnished precise timing and firing signals to the experimental programs.

- The Assembly and Arming Support Group supervised the handling and storing of the nuclear devices and the final preparations for firing.

- The Sandia Support Group supplied some technical weapons support.

The AEC and FCDA/CETG projects at SMOKY included a small number of DOD personnel. The AEC projects were mainly those necessary to emplace, arm, and fire the nuclear device, and to measure the outputs needed for evaluating device performance. The FCDA projects were those involving measurement of effects related to the safety of the civilian populace. This group (as well as AEC-sponsored test groups) was supported by the AEC Support Director in the Nevada Test Organization. The AEC support group used contractors extensively.

Overall, 58 projects were conducted at shot SMOKY. Department of Defense personnel took part in the projects listed below. Best estimates of the numbers of DOD participants are:

- 228 onsite DOD personnel were involved in the ten projects conducted by AFSWP Field Command Military Effects Group, NTO.

- Probably less than 25 DOD personnel assisted in five of the 16 scientific, diagnostic, and technical projects conducted by the three AEC test groups of the NTO.

- Approximately 61 DOD personnel participated in 15 of 22 projects conducted by the Civil Effects Test Group.

- 17 DOD personnel took part in the five operational training projects conducted by the Air Force, Navy, and Marine Corps under the NTO.

- 930 airmen and ground personnel of the AFSWC provided requisite air support to the NTO Test Manager and to projects of the NTO and EDR.

- 1,144 soldiers took part in the Army's demonstration test of the armored task force (Task Force WARRIOR) conducted under Exercise Desert Rock.

- 1,040 armed services personnel participated as exercise troops or observers in the remaining four projects conducted under Exercise Desert Rock.

- 30 DOD personnel from the NTO and Camp Desert Rock, (soldiers from the First Radiological Safety Support Unit) provided essential support services during SMOKY and the subsequent recovery operations.

The Los Alamos Scientific Laboratory Test Group conducted four diagnostic projects at SMOKY. DOD personnel took part in two of these projects:

- Project 11.2 Radiochemistry Sampling
- Project 16.2 Temperature Measurements-Portable Recorder

The University of California Radiation Laboratory Test Group conducted 12 projects, and DOD personnel from AFSWC assisted in two of them:

- Project 21.2 Radiochemistry Sampling
- Project 21.3 Rocket Sampling

The Civil Effects Test Group conducted 22 projects at SMOKY. DOD personnel assisted in 15 of these projects, sometimes providing advice and consultation in the planning stages, and sometimes taking an active part in fielding project equipment and collecting information at the Nevada Test Site. The 15 projects in which DOD advisors or staff were involved were:

- Project 30.5 Shelter and Structure Blast Instrumentation
- Project 33.2 Missiles Secondary to Nuclear Blast
- Project 33.3 Displacement Potential of Blast
- Project 34.2 Comparison Tests of Reinforcing Steels
- Project 34.3 Comparative Responses of Static and Dynamic Loadings
- Project 37.2 Biological Aspects of Fallout Phenomenology

- Project 37.2a Identification and Documentation - Physical Aspects of Fallout
- Project 37.4 Measurement of Fast Neutron Doses by Germanium Dosimeters
- Project 37.5 Measurement of Ionizing Radiation by Chemical Methods
- Project 37.6 Application of Radio-Ecological Techniques
- Project 39.1 Gamma and Neutron Radiation Measurements
- Project 39.1a Gamma Dosimetry by Film-Badge Techniques
- Project 39.1b Neutron Dosimetry by the Threshold-Detector Technique
- Project 39.5 Radiation Dosimetry for Human Exposures
- Project 39.9 Remote Radiological Monitoring

AFSWP technical experimentation comprised a major DOD involvement at the nuclear tests in PLUMBBOB. Ten AFSWP technical projects were active in SMOKY:

- Project 1.8 Effects of Rough and Sloping Terrain on Airblast Phenomena
- Project 1.9 Spectra of Ground Shocks Produced by Nuclear Detonations
- Project 2.3 Neutron Flux from Selected Nuclear Devices
- Project 4.3 Secondary Missiles Generated by Nuclear-produced Blast Waves (This project administrated by CETG as Project 33.2)
- Project 5.3 In-flight Structural Response of the FJ-4 Aircraft to a Nuclear Detonation
- Project 5.4 In-flight Structural Response of the Model A4D-1 Aircraft to a Nuclear Detonation
- Project 5.5 In-flight Structural Response of an F-89D Aircraft to a Nuclear Detonation

- Project 6.4 Accuracy and Reliability of the Short-baseline NAROL System
- Project 8.3b Instrumentation for Measuring Effects Phenomena Inside the Fireball
- Project 9.1 Support Photography

Some of these projects entailed entry into forward areas both before and after the detonation. Projects 5.3, 5.4, 5.5 and 9.1 required aircraft to fly over the forward area of operations in conformance with the NTO radiological safety criteria and procedures. The location of the AFSWP experiments at SMOKY is indicated in Figure 1-1. The remaining DOD involvement, as indicated earlier, was divided between AFSWC and EDR.

The Air Force, Navy, and Marine Corps conducted five operational training projects around the SMOKY detonation. Some of these projects required only that aircrews fly their aircraft over southeastern Nevada at the time of the detonation to observe the fireball and the rise of the resulting nuclear cloud. Others required Armed Services personnel to monitor the electro-magnetic pulse produced by the detonation from stations located several hundred kilometers away from the test site. The five operational training projects included:

- Project 51.3 Navy Heavy Attack Indoctrination (AJ/A3D)
- Project 53.1 Aerial Sampling Mission
- Project 53.7 Indirect Bomb Damage Assessment
- Project 53.8 Indirect Bomb Damage Assessment
- Project 53.9 Photographic Reconnaissance Training.

Finally, AFSWC provided air support to test activities at NTS. Air Force personnel flew cloud tracking and sampling missions directly related to weapon diagnostics, and AFSWC squadrons provided air base support for the AFSWP projects which used aircraft. In addition, AFSWC-supported Air Force units conducted operational training exercises in conjunction with the nuclear testing.

AFSWC provided air support to 14 projects at SMOKY: 5.3, 5.4, 5.5, 9.1, 11.2, 21.2, 21.3, 50.1, 50.8, 51.3, 53.1, 53.7, 53.8, and 53.9 (all listed on previous pages), and supplied radio relay assistance to Program 37.

CHAPTER 2
EXERCISE DESERT ROCK OPERATIONS

2.1 DESERT ROCK PROJECTS

The DOD participation at SMOKY under the Desert Rock Organization included troop maneuvers, observer programs, technical service projects, some training projects, and support activities (see Table 2-1). These efforts were not to interfere with the AEC or other DOD activities at the test site. The following project summaries provide information from such sources as the Desert Rock VII and VIII Final Report (9); The Report of Test, Infantry Troop Test, Exercise Desert Rock VII and VIII (27); Operation Order 17, SMOKY, Desert Rock VII and VIII (23); and After-Action Reports by Technical Service Chiefs, Operation PLUMBBOB (32a). In most cases, the available documentation provides adequate descriptions of technical results achieved but incomplete detail as to personnel activities with associated potential for radioactive exposure.

2.1.1 Task Force BIG BANG, the HumRRO Project

This involved a research team from HumRRO, a Department of the Army contractor, and a provisional company from the 82nd Airborne Division, Fort Bragg, North Carolina. The HumRRO project was to compare soldiers' performance of several basic military tasks before and immediately after they observed a nuclear detonation. The tasks included disassembling and reassembling a rifle, throwing a hand grenade, and traversing an infiltration course. In addition, the test was to include observing the men's reaction to crawling through an area which they thought was contaminated with fallout while traversing the infiltration course. Although the HumRRO team and soldiers completed their preparation for the SMOKY shot, the predicted fallout pattern caused their participation to be cancelled the preceding evening. Consequently, they observed the firing from News Nob (located in Yucca Pass, 18 miles from ground zero), along with other observers.*

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*The HumRRO test was rescheduled and completed during the GALILEO shot on 2 September 1957. A detailed discussion of this project is included in the GALILEO shot volume.

Table 2-1. EXERCISE DESERT ROCK VII AND VIII PROJECTS, SHOT SMOKY.

Program Type	Project	Title	Conducted by	DOD Personnel*
Troop Test	50.1	Infantry Troop Tests (Task Force Warrior)	U.S. Army Continental Command	1,144†
Troop Observers	50.2	Troop Observers (Includes Canadian Army Observers)	U.S. Army Continental Command	505§
Technical Service Projects	50.3	Evaluation of Medium Range Detonation-Detection and Cloud Tracking Systems	U.S. Army Signal Research and Development Laboratories	25
↓	50.7	Test of Ordnance Material	Chief of Ordnance U.S. Army; Ballistic Research Laboratories; Aberdeen Proving Grounds	100 (est.)
	50.8	Detection of Atomic Burst and Radioactive Fallout	U.S. Army Artillery and Guided Missile School; U.S. Army Air Defense Board; Air Weather Service	557

* Numbers obtained from Reference 9 (except for Project 50.7); not in agreement with Reference 10.

† Includes Canadian participants.

§ Includes 51 Camp Desert Rock Personnel.

2.1.2 Task Force WARRIOR (Project 50.1)

This was a provisional unit established to test and, to a lesser extent, develop infantry airlanded tactics and techniques for the atomic battlefield. The exercise was originally conceived to employ an infantry battalion. Along with other Army units in the late 1950s, however, the parent unit of the task force (1st Battle Group, 12th Infantry Regiment, 4th Infantry Division, Fort Lewis, Washington) was restructured under a concept known as ROCID (Reorganization of Current Infantry Divisions). Conceived because of the existing international situation, the ROCID concept directed the Army to restructure its fighting forces primarily for nuclear-weapons-supported warfare on the plains of Europe. Thus, shot SMOKY provided the Army with a unique opportunity to exercise a ROCID

unit in the environment of a nuclear weapon detonation. As the planning progressed, the scope of the exercise was reduced and the participating maneuver task force eventually became the size of a reinforced infantry company (Company C, of the 1st Battle Group, 12th Infantry Regiment). Figure 2-1 shows the Task Force WARRIOR Organization. The Task Force WARRIOR project is sufficiently documented so that it is convenient to divide the activities into pre-shot, shot, and post-shot operations.

Pre-Shot Operations. The task force and helicopter units assigned to support the maneuver arrived in late July. At that time, they trained in airlanded operations. Together, the task force and helicopter units progressed from the basic tasks of loading men and equipment, to the larger task of fully rehearsing several plans for the tactical maneuver. In accordance with the scheduled shot date of 19 August, the soldiers prepared approximately 115 defensive positions on 12 and 13 August. Communications equipment, vehicles, and weapons were installed in and around the positions. The items were to be examined after the shot to determine how effectively the positions protected the equipment. Figure 2-2 shows the locations of these positions, which range from 820 to about 1,850 meters to the west and north of ground zero. The men spent a total of 7.5 hours digging the positions (trenches) using only tools and equipment organic to the military units. Because the soil was rocky, only about 60 percent of the positions were completed; the digging was difficult and the progress was slow (27). The troops finished all pre-shot operations by Friday 16 August, in preparation for the shot scheduled to follow on Monday. For various reasons, including contamination from shot SHASTA (fired 18 August 1957) SMOKY was postponed to a date at least 10 days after SHASTA. In the interval between pre-shot operations and shot SMOKY the task force observed shot DOPPLER (23 August 1957) from trenches 2,850 yards from DOPPLER GZ.

Shot Operations. Shot SMOKY was fired at 0530 on 31 August 1957 (Figure 2-3). Although trenches for Task Force WARRIOR had been prepared 4400 yards southeast of the SMOKY tower, the predicted fallout pattern for 31 August, based upon available weather data, called for heavy fallout to blanket the prepared trenches and the HumRRO test site. As can be seen from the fallout plot in Figure 2-3, these areas were heavily contaminated and would have posed serious

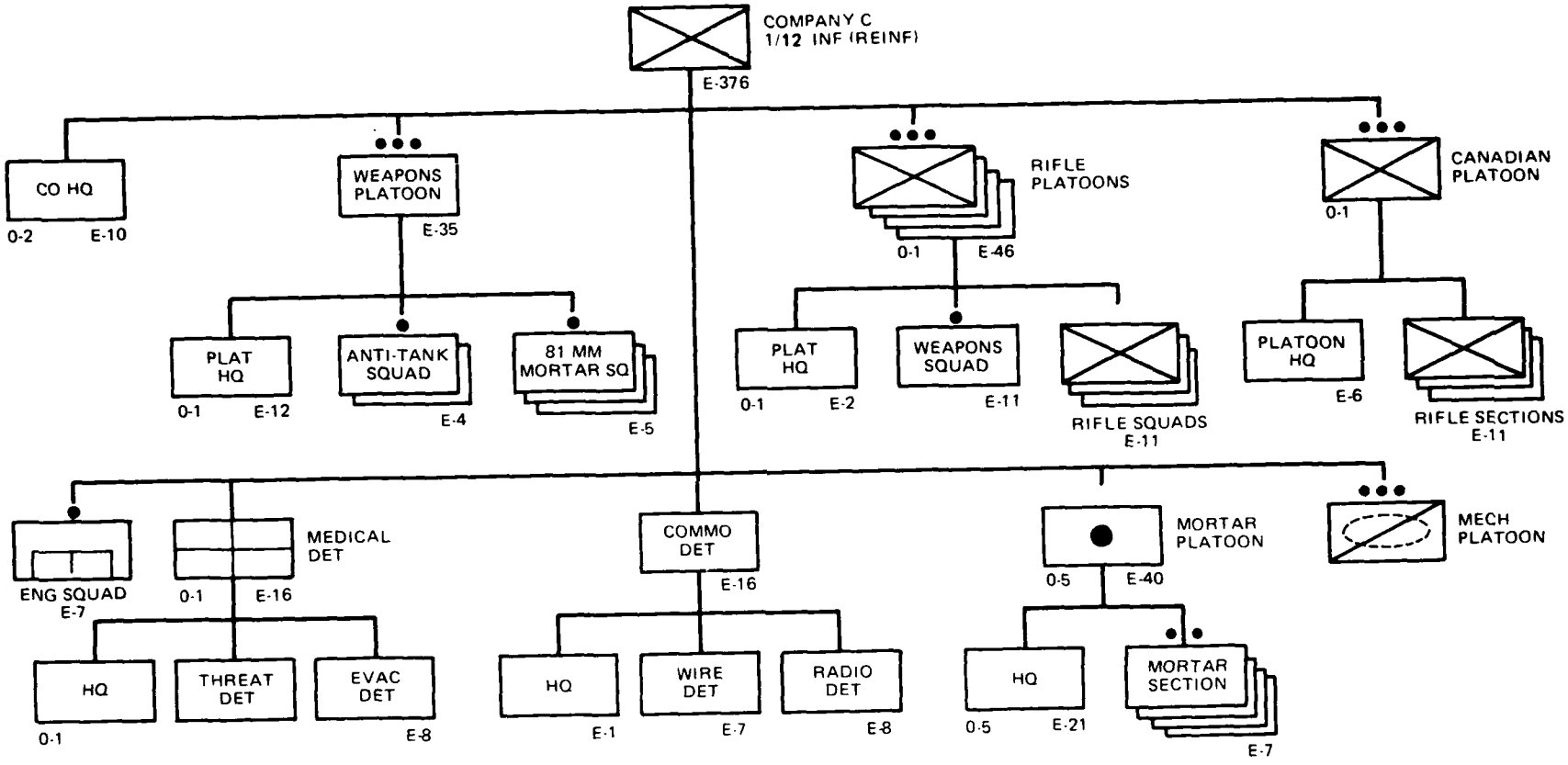


Figure 2-1. TASK FORCE WARRIOR ORGANIZATION.

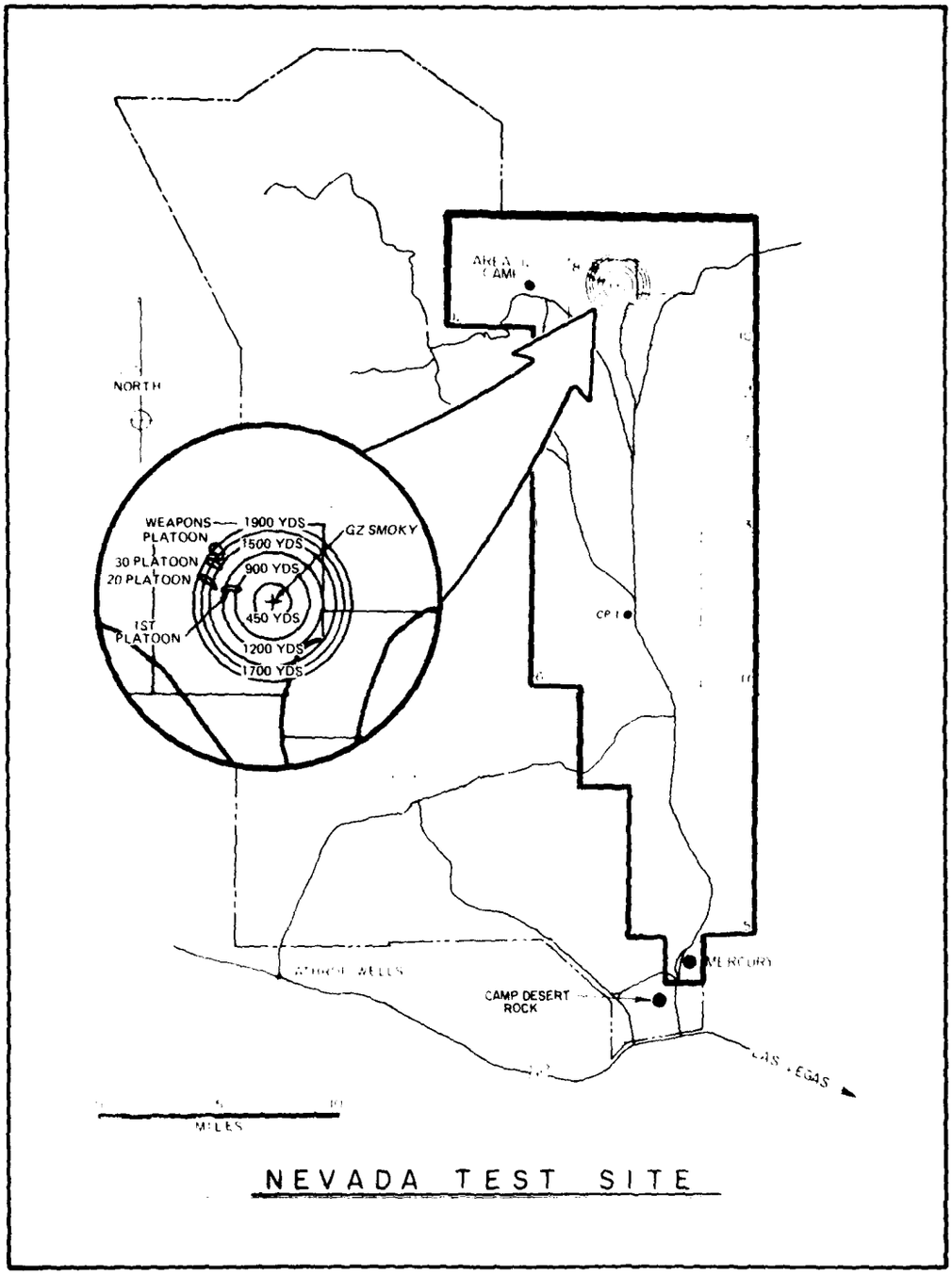
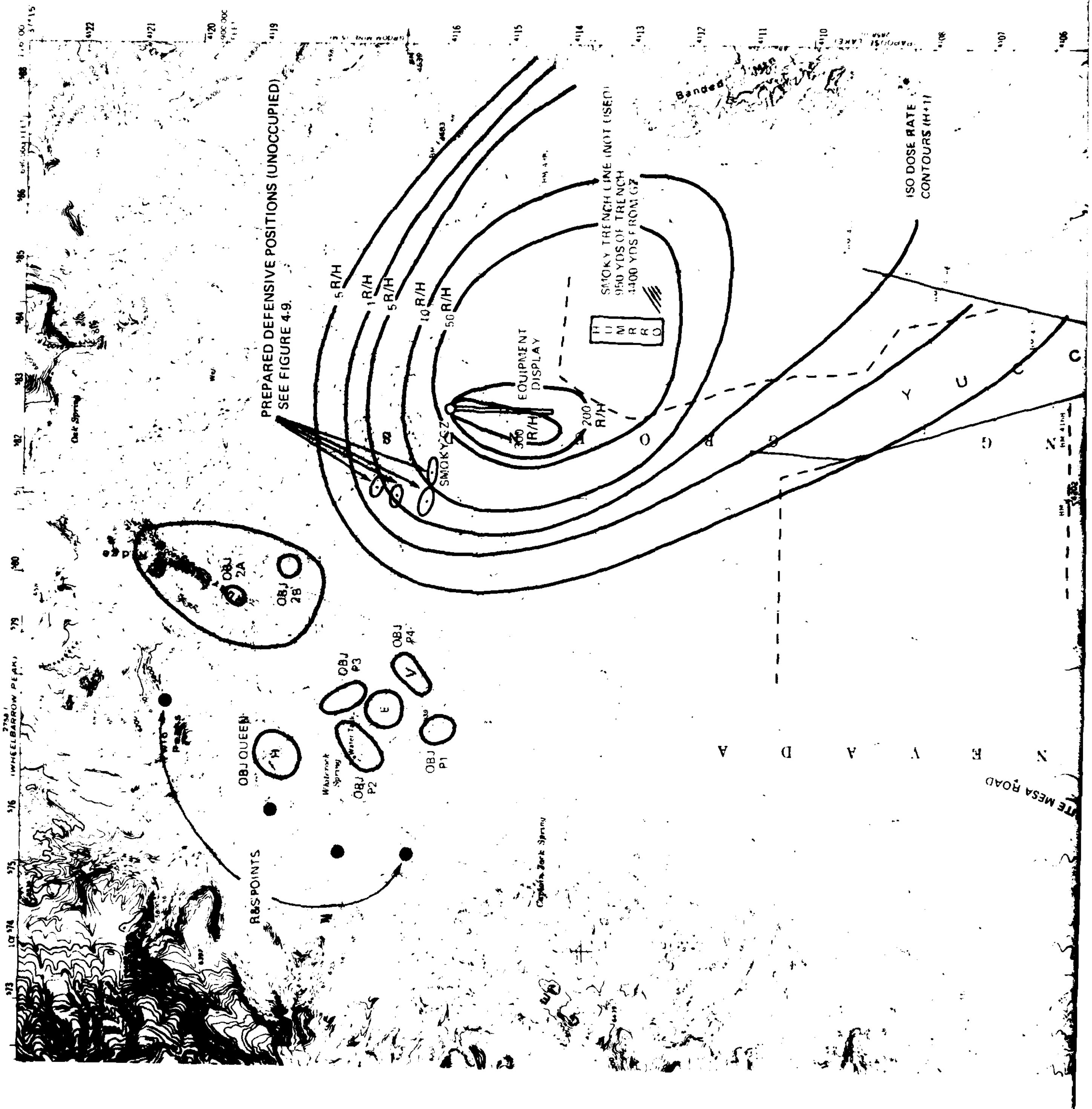


Figure 2-2. PHASE I DEFENSIVE POSITIONS.



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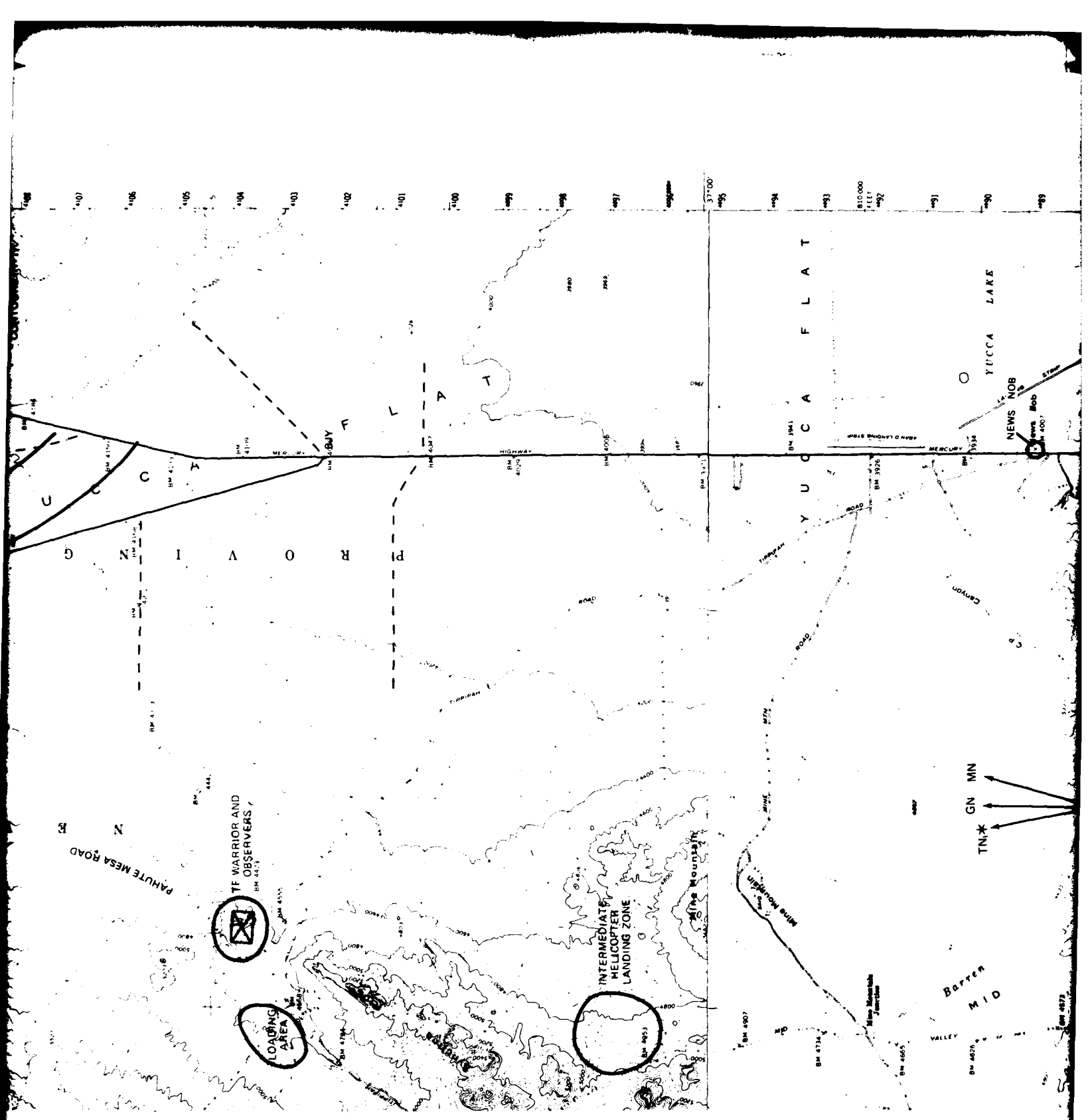
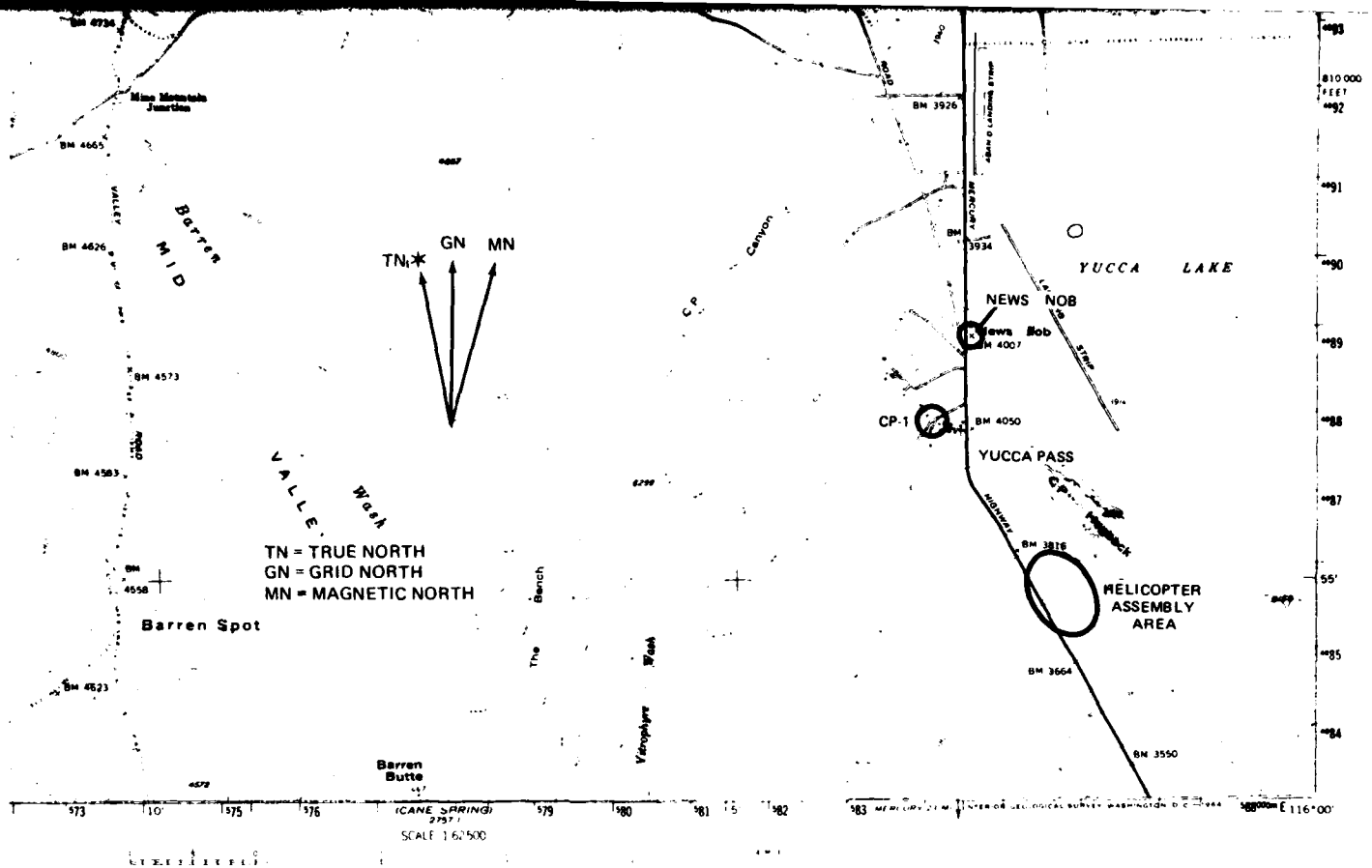


Figure 2-3. SITUATION MAP, TA

2



2-3. SITUATION MAP, TASK FORCE WARRIOR TROOP MANEUVER.

* THE ISODOSE RATE CONTOURS SHOWN ARE FROM DASA 1251 - REFERENCE 20. ALTHOUGH FALLOUT WAS NOT COMPLETE AT H+1 HOURS, READINGS TAKEN AFTER FALLOUT WAS COMPLETED WERE NORMALIZED BACK TO H + 1 HOURS FOR USE IN DOSE CALCULATIONS.

radiological control problems if used. As a result, the original operating plan, Plan A, had to be abandoned for the alternative plan, Plan B. The overlay showing troop locations for Plans A and B is reproduced in Figure 2-4.* According to Plan B, the task force and other observers witnessed the shot from an area off Pahute Mesa Road (Figure 2-3), approximately eight miles southwest of GZ. (Coordinates for the observation area were 766053. See the situation map, Figure 2-3). On the day of the shot, the main body of troops left Camp Desert Rock by 0100 hours and were in the observer area by 0330. The 3rd Transportation Battalion (Helicopter), which provided airlift support and Pathfinder functions for Task Force WARRIOR (Figure 2-5), was positioned in the helicopter assembly area on the south side of the saddle between Yucca Flat and Frenchman Flat, approximately 20 miles south of GZ and about two miles south of News Nob. Task Force BIG BANG (the HumRRO Project), consisting of the Provisional Company of the 82nd Airborne Division, observed the shot from News Nob.

Post-Shot Operations. Fifteen minutes after the shot, the Pathfinders boarded the helicopters for airlift from the Task Force WARRIOR observation points to the primary objective area. Flying in a northerly direction, the Pathfinders, accompanied by radiological safety personnel, landed in the objective area at 0617, after conducting a preliminary aerial radiological reconnaissance. The Pathfinders executed their mission of delineating safe landing sites for the main body of the airlift to follow. Rad-safe monitoring showed the maneuver area to be safe, and the Pathfinder team leaders relayed this information to the Task Force WARRIOR commander.

At 0550 hours, Task Force WARRIOR began moving overland from the observation point to the loading area (Figure 2-3), arriving there at 0605. Between 0621 and 0627, the troop-lift aircraft left the helicopter assembly area; they landed in the intermediate landing zone 20 minutes later. After a 15 minute hold, the helicopters began flying toward the troop loading area, arriving there between 0700 and 0711. The first airlift (fourteen H-34 and eight H-21 helicopters) carried three rifle platoons and the weapons platoon. It left the loading area beginning at 0704 and reached the landing zones beginning at 0715

*This figure is not to scale and is provided only to show the relative locations of Plan A to Plan B sites; Plan B sites are essentially southwest of those in Plan A. This figure should not be used to follow the maneuver scenario.

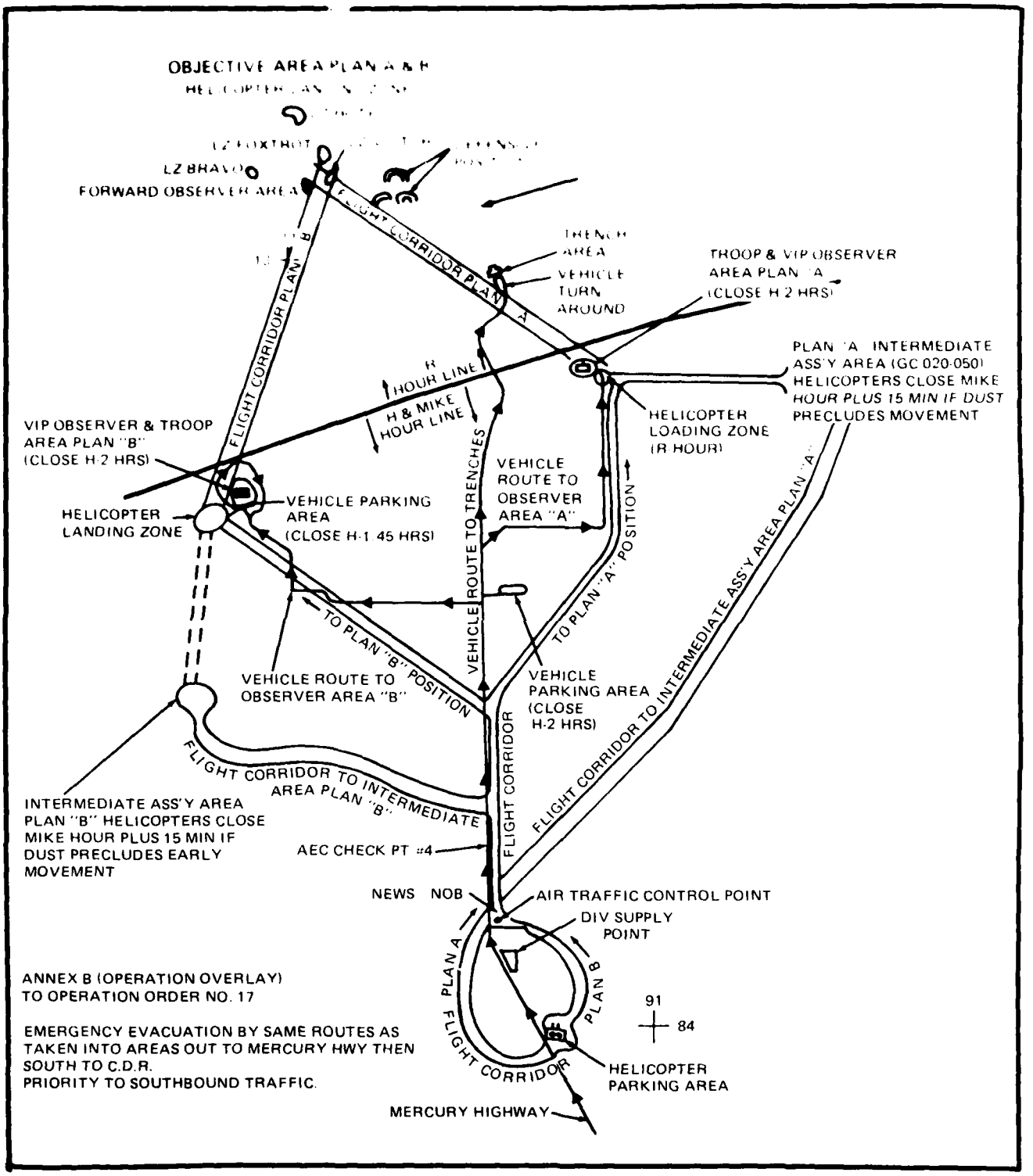


Figure 2-4. PROJECT 50.1 COMBAT TEAM EXERCISE (INFANTRY BATTLE GROUP TEST) SHOT SMOKY.

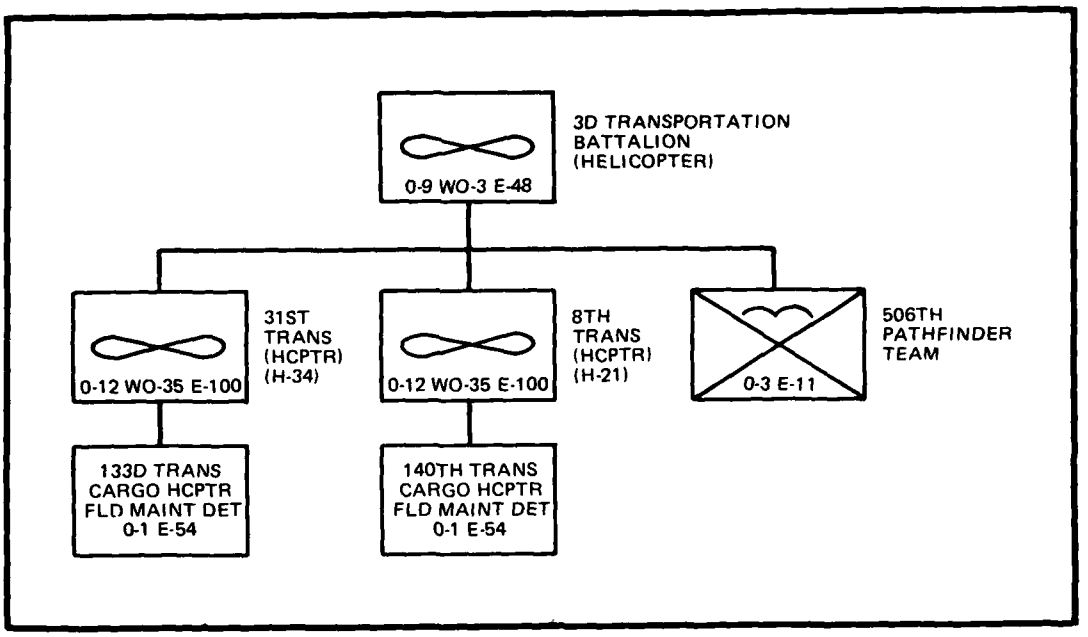


Figure 2-5. THIRD TRANSPORTATION BATTALION ORGANIZATION.

(Figure 2-3). Task force activities proceeded as follows (paraphrased from reference 11):

> At 0715, the 2nd platoon with an attached 81 mm mortar squad, arrived at landing zone (LZ) VICTOR. They secured the high ground (altitude of 5,055 feet) of Objective P4 by 0720. (Objective P4 was 4,100 meters west of SMOKY GZ). At that time, the 2nd platoon prepared for the final ground assault on Objective 2B, a shoulder of Quartzite Ridge.
>
> At 0716, the 3rd platoon landed at LZ ECHO. It secured the high ground (5,303 feet) of Objective P3 by 0740. (Objective P3 was 4,700 meters northwest of SMOKY GZ). At that time, the 3rd platoon prepared for the final ground assault on Objective 2A, the southern end of Quartzite Ridge.
>
> At 0718, the 1st platoon arrived at the airhead. One element landed on the high ground of Objective P2 (5,100 feet),

overlooking Whiterock Spring. A second element landed on the high ground of Objective P1 (4,955 feet), which was 1,200 meters to the south. The objectives were secure by 0723. The entire platoon remained at these locations, 5,200 and 5,600 meters west of SMOKY GZ, until exercise termination at 0945.

Two increments of the Weapons Platoon arrived at LZ ECHO. The first increment landed at 0723 and the second increment landed at 0732.

At 0740, these three platoons were in position on the four objectives - P4, P3, P2, and P1 (Figure 2-3).

The second lift carried the remainder of the task force. Seventeen H-34 and eleven H-21 helicopters, including some from the first airlift, participated. It began leaving the loading area at 0731. Task force activities proceeded as follows:

At 0740, the Canadian Army Platoon landed at LZ HOTEL, which was 6,000 meters west-northwest of ground zero. At 0800, it occupied Objective QUEEN, about 500 meters to the north, and the reconnaissance and security positions on or near Twin Peaks, 1,000-1,500 meters to the north (Figure 2-2). It remained in these positions, 6,000-6,600 meters northwest of GZ until the exercise was over.

At 0745, the Reconnaissance Platoon, the engineer squad, and the two patrols landed some elements on or near the road west of Whiterock Spring. These units secured the road and occupied two southern reconnaissance security points overlooking the road, 6,500 meters west of GZ, until exercise termination (Figure 2-2).

At 0746, the 4th platoon and the medical detachment landed at LZ ECHO. At 0805, the 4th platoon split into two increments to relieve the 3rd platoon on Objective P3 and the 2nd platoon on Objective P4. The relief was complete by 0818. The 4th platoon remained at these positions while the 2nd and 3rd platoons assaulted Objective 2 on Quartzite Ridge.

At 0757, four of the seven aircraft carrying the Mortar Platoon landed at LZ ECHO. The other three helicopters reached ECHO at 0815 after first landing by mistake at HOTEL. By 0826, the mortar platoon was in position.

At 0814, task force headquarters and the communications detachment landed at LZ ECHO. Until exercise termination at 0945, task force operations were controlled from the command post, which had been established on the northern side of the landing zone, 5,000 meters from ground zero.

With the exception of the mislanded mortar platoon squads and one aircraft picking up the weapons that platoon soldiers left in the loading area, this landing completed the troop lift.

Several VIP observers, who were with Task Force WARRIOR at shot time, flew to the objective area early in the airlift to observe the landing operations and the securing of the airhead.

With the completion of the airlift, the ground maneuvers began. At 0830, the task force commander ordered his 2nd and 3rd platoons (then located Objectives P3 and P4) to seize Objectives 2A and 2B. The platoons began moving immediately; meanwhile, the 4th platoon had already moved from the reserve assembly area at landing zone ECHO to replace these platoons on Objectives P3 and P4. At 0915, the task force commander reported that his 2nd and 3rd platoons had advanced to the points permitted by Rad-safe personnel and had been halted prior to seizure of Objective 2. The exact location and the radiation level for this halt is not specified in the troop test report (27). Thereafter, with the exception of resupply and evacuation helicopter flights which had been underway since the first landings, no further troop movement occurred until the exercise was terminated at 0945. It has not been determined how and when the troops were moved out of the area following the exercise. The Operation Order for SMOKY (23) indicates that, if the alternate objective was used, troops were to be airlifted from their objectives when the problem ended, to a truck convoy loading area near coordinates 87160 (Figure 2-3).*

Based on the pre-exercise decision to limit the size of the participating unit to that of a reinforced rifle company, the task force was resupplied by helicopters operating from a simulated division distributing point. This Aerial Supply Distributing Point, with an adjacent helicopter loading site, was established to effect the aerial supply. The supplies accompanying the task were provided by its normal ground vehicles. Follow-up supplies were transported by truck to the Aerial Supply Distributing Point where they were held until the helicopters arrived. As each helicopter landed, a truck moved the appropriate

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*No documentation of such a move was found; this location is within a fallout area which had not been cleared for entry at 0915. In addition, responses to Army questionnaires indicate that the troops walked to LZ ECHO and were taken from there by truck.

load to the aircraft. The loading detail then either placed the boxes into the helicopter or rigged a sling load, as appropriate.

The Aerial Supply Distributing Point contained 27 tons of supplies for distribution to the task force. Of these supplies, 2.5 tons (three sling loads) were automatic resupply, delivered on a schedule established by the maneuver headquarters. They were, in fact, delivered between 0757 and 0818 hours. The remaining 24.5 tons were prepared for delivery as on-call supplies. Of these, six tons were delivered between 0829 and 0940 at the request of the task force commander. All of the supplies, except water, were simulated by sand-filled boxes tagged to show their weight and content. Water was supplied in 5-gallon cans. Only water and simulated ammunition were flown to the task force before the exercise terminated. Once the additional six tons of supplies requested by the task force commander were delivered, all additional requests were denied in anticipation of the termination of the exercise.

2.1.3 The Troop-Observer Indoctrination Program (Project 50.2)

The objective of this project was to acquaint representatives from the Armed Forces with the effects of nuclear weapons and to allow them to observe a nuclear detonation. Personnel selected to participate in this program would normally include the following:

- Troop, aircraft, and ship commanders
- Staff officers whose duties would require familiarity with the employment of nuclear weapons
- Members of fire support units who would plan the employment of nuclear weapons.

American civilian and Canadian military observers also participated in SMOKY. The Canadians did not have security clearances for all of the information presented and so were briefed separately. The following project 50.2 personnel observed SMOKY (9):

Army	384
Navy	3
Air Force	15
Marine Corps	9
Civilian	3
Canadian	43
Camp Desert Rock	51
TOTAL	508

Visitors processed by the Desert Rock Visitor's Bureau, although not a part of the observer project, are included in these figures.

The observers began arriving three days before the date scheduled for SMOKY. Because unfavorable weather delayed the firing for three days, some observers waited as many as six days to observe the shot. Pre-shot activities included orientation classes and visits to equipment display areas.* The Project 50.2 equipment displays for SMOKY included 120 items of military field equipment, arrayed on a line running due south from ground zero for a distance of about 3,000 yards (Figure 2-4).

The observers were originally scheduled to occupy the trenches prepared for Task Force WARRIOR. When the decision was made to follow Plan B, the observers were rescheduled to watch the shot from News Nob, 18 miles south of ground zero.

During the post-shot phase, entry into the display area to observe the weapons effects would have meant entering a radiological exclusion area (Radex); this is an area for which entry is controlled by a Rad-safe station. (The location of the displays relative to the radiation pattern is shown in Figure 2-3.) Such a move would have required monitoring and protective clothing. While there is no documentation to indicate that any of the observers were allowed into the display area, it is certain that photographers did enter at some time after the burst, since photographs of the weapons effects appear in reference 9.

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*These activities are discussed in the PLUMBBOB series volume.

2.1.4 Technical Service Projects*

During Desert Rock Exercise VII and VIII, the Army Technical Services conducted several projects which were directly related to the missions which those services would conduct in nuclear warfare. These projects also concerned determining the effects of nuclear weapons on standard Army equipment items. The Desert Rock Exercise Director was responsible for overall supervisory coordination, as well as general administrative and logistical support of the tests. The Technical Services appointed Project Officers to direct the test operations. At SMOKY, only three Technical Service Projects were activated:

- Evaluation of Medium Range Detonation-Detection and Cloud Tracking Systems (Project 50.3)
- Test of Ordnance Material (Project 50.7)
- Detection of Atomic Burst and Radioactive Fallout (Project 50.8).

Project 50.3: (Evaluation of Medium Range Detonation-Detection and Cloud Tracking Systems). Experimentation for this project was designed to test the Army's capability to evaluate nuclear detonations, to track radioactive clouds, and to test the fallout prediction methods and instruments developed by the U.S. Army Signal Laboratory at Ft. Monmouth, NJ. This project was, in fact, sponsored by the Signal Corps, U.S. Army, and 25 of their personnel participated (9). The project report shows that only two radar sites provided data for SMOKY (3). One, manned by Project 50.3 personnel, was located near Hiko Village, which is off the Nevada Test Site and approximately 41 miles northwest of GZ. The other site, known as Angel's Peak Number 1, was operated by the Air Force as part of the Control and Warning System for Norton Air Force Base, California. Project personnel did not operate this radar but were permitted to photograph the scope display during SMOKY. In addition to the personnel at these two radar sites, fallout prediction personnel were located in a mobile van at Camp Mercury, 42 miles south of GZ. Meteorological personnel were located near Alamo, Nevada, situated to the northeast of the NTS. The Desert Rock Rad-safe Section provided film badges for the project personnel. Since travel to the sites may have

*The entire series of Technical Service Projects (Projects 50.3-50.8) is discussed in the PLUMBBOB series volume.

required crossing the NTS forward areas, the AEC Rad-safe and security procedures for travel to and from these sites would apply, particularly, for the fallout prediction group at Camp Mercury.

Project 50.7: (Test of Ordnance Material). This project, sponsored by the Ordnance Corps, U.S. Army, tested blast, thermal, and radioactive effects of nuclear explosions on ordnance equipment. Project 50.7 was directly related to AFSWP Projects 1.8 and 2.4.* These tests had several objectives:

- Evaluating the shielding provided by armored vehicles and shielding materials in order to determine the protective value of placing such vehicles and materials over foxholes
- Examining the effects of neutron radiation on fuses
- Collecting data on blast damage to armored vehicles.

The SMOKY section of Project 50.7 was concerned specifically with collecting data on blast damage to armored vehicles while AFSWP Project 2.4 was concerned with the other two objectives. Apparently only one person participated in Project 50.7 at SMOKY (9). As stated above, Project 50.7 was also related to AFSWP Project 1.8 (this program is discussed in Chapter 3). At SMOKY, two unmanned M-48 tanks were tested which were common to both Projects 50.7 and 1.8. Blast damage tests consisted of placing tanks at strategic locations and then examining the damage resulting from the blast. One M-48 tank was placed 1,231 feet from ground zero and another was placed in a gully, 2,800 feet from ground zero (Figure 3-1). The tank closest to ground zero was rolled over onto its top and suffered extensive damage while the tank furthest from the blast was essentially undamaged. Figure 3-1, in conjunction with Figure 2-3, shows the relationship of the experiment to the contaminated area. Project 50.7 did have a tank recovery vehicle which could have been used after the blast to remove the tanks from the area.†

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*Project 2.4 was not active at SMOKY.

†To recover and photograph the tanks soon after the blast would have necessitated entry into a radiological exclusion area, requiring subsequent decontamination of personnel and equipment. While such a recovery effort was certainly probable, it has not been documented.

Project 50.8: (Detection of Atomic Burst and Radioactive Fallout). This project was sponsored by the Artillery and Guided Missile Center, U.S. Army. Other participating agencies included the Chemical Corps, the Air Defense Board, the Artillery Board, and the Air Weather Service. The purpose of Project 50.8 was to determine how effectively Army units could predict fallout and locate and estimate the yield of nuclear weapons. In this connection, secondary objectives included determining the appropriate organization, equipment, and input data necessary to perform these tasks.* Desert Rock provided Rad-safe support for this project.

The Desert Rock VII and VIII Final Report lists 557 participants for Project 50.8 (9). This total is suspect, however, since records of personnel with film badges issued as of 31 August 1957 include only 130 Project 50.8 personnel. For the period including 31 August 1957, the film badge readings for these personnel were in the 0-400 mR range. It appears unlikely, therefore, that any of these personnel entered or had any extended stay in a radiological exclusion area. The Air Support Group Air Mission Summary Report for SMOKY shows that four H19 helicopters and one L20 light aircraft flew in support of Project 50.8 (11).†

2.2 TRAINING PROJECTS

Nuclear testing at the Nevada Test Site provided an excellent opportunity to train individuals in the use of various radiological monitoring techniques and how to conduct surveys of radiologically contaminated areas. For PLUMBBOB, the military services usually operated three radiological training projects, but for SMOKY, only the Army Camp Desert Rock Rad-safe school was in operation. During the pre-shot period, the Pathfinder Teams assigned to Task Force WARRIOR were trained in the procedures necessary for radiological monitoring. Pathfinders are specially trained personnel who go into landing areas before the arrival of airlifted or air-dropped units to evaluate selected landing zones and mark appropriate areas so that the incoming pilots can recognize them. As a result of the monitoring training, the Pathfinders were able to determine,

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*The PLUMBBOB series volume includes a discussion of this project.

†While not documented, it would be reasonable to conclude from this report that a portion of the 130 persons participated in aerial surveys that were conducted to provide the data necessary to compare the various fallout prediction techniques under consideration at that time.

within some established safety limit, that the selected landing zones were safe for whatever landing was to be made. How often this training occurred in contaminated areas is not specifically known. However, use of the previous shot areas for such training was not unusual. Desert Rock Rad-safe personnel provided the training and film badging and, in addition, accompanied the Pathfinders into the landing zones during the troop exercises. Activities of the Pathfinders in relation to Task Force WARRIOR have been more specifically covered in section 2.1.2.

2.3 SUPPORT ACTIVITIES

Camp Desert Rock support personnel may have been exposed to some ionizing radiation during pre-shot and post-shot activities. A variety of types of support troops and personnel were involved at SMOKY, e.g., engineers, military police, quartermasters, transportation, and signal companies. While most unit activities were not documented, functions of the important units were outlined in the Operation Order for SMOKY (23):

- The 50th Chemical Platoon provided five motorized; radio-equipped, Rad-safe monitor teams to SMOKY; two teams were assigned the ridge at 753042, two teams were sent to the helicopter landing zones for the alternate troop maneuver, and one team was assigned to the field decontamination station near News Nob (Yucca Pass). In addition, the 50th Chemical Platoon provided one monitor per Pathfinder helicopter. The remaining personnel of the 50th Chemical Platoon operated the field decontamination station near News Nob.

- The 8th Field Hospital provided five ambulances and medical personnel to administer field medical treatment and to evacuate Camp Desert Rock personnel, observers, and project personnel. Ambulances were located at both Task Force WARRIOR and News Nob observer sites.

- The 293rd Military Police Company provided 27 traffic control points and two parking details. These provisions enabled the staff and observers to move to the observer area, and for Task Force WARRIOR to move to the observation and helicopter assembly area.

- The 232nd Signal Company and attached signal teams provided all Desert Rock radio and wire

communication services. (These services were coordinated with the Department of Defense staff personnel at Camp Mercury.) The 2nd Signal Platoon pictorially documented the before, during, and after-shot activities. Equipment was installed and adjusted to transmit video scenes to the troops at News Nob. However, when the change to Plan B was made, insufficient time remained to relocate and adjust the equipment. Therefore, no televised scenes were transmitted. The photo-dosimetry team processed the film badges issued to all Desert Rock participants.

- The 26th Transportation Battalion provided three vehicle march units which transported personnel to and from Camp Desert rock and the observer areas. The three units consisted of tactical Army vehicles, large-capacity buses, and medium-capacity buses.

CHAPTER 3
NEVADA TEST ORGANIZATION OPERATIONS

While the primary purpose of shot SMOKY was to test a particular design for a nuclear device, it also provided the opportunity to perform tests and activities of interest to the DOD's national defense program. DOD programs were coordinated at the Nevada Test Site by the Field Command Armed Forces Special Weapons Project representative, who was the Deputy of the AEC Test Manager for Military Matters. There were three major types of DOD activities within the Nevada Test Organization (NTO):

- The Field Command Weapons Test (FCWT) group in the Nevada Test Organization performed extensive experimental work on the military effects of nuclear weapons.
- The Air Support Group from Air Force Special Weapons Center coordinated air sampling, cloud tracking, and air security programs.
- The Visitors Bureau was a joint AEC/DOD activity under the AEC Test Manager.

DOD personnel participated in both DOD-sponsored projects and in projects not sponsored by the DOD, such as those conducted by the AEC and the Federal Civil Defense Administration. For example, 38 military personnel were provided from the U.S. Army First Radiological Safety Support Unit, Fort McClellan, Alabama. These personnel trained on-the-job as monitors in the Rad-safe Division of REECo, the Rad-safe contractor to NTO. Other military personnel were assigned to the Los Alamos Scientific Laboratory and University of California Radiation Laboratory test groups.

3.1 DOD/AEC PROJECTS

Most AEC programs at SMOKY were executed by laboratories and contractors such as LASL, UCRL, Sandia, and Edgerton, Germeshausen, and Grier (EG&G). In addition, the Civil Effects Test Group (CETG) conducted programs under the auspices of the AEC for the Federal Civil Defense Administration. These programs involved a small number of DOD personnel. This section describes the Military Effects Program at SMOKY and emphasizes those activities which may have placed personnel in a position to receive some dose of ionizing radiation.

3.1.1 FC/AFSWP Military Effects Program at SMOKY. The Armed Forces Special Weapons Project through the Director, Weapons Effects Testing, Field Command/ AFSWP, was responsible for the military weapons effects test projects which were conducted during SMOKY. AFSWP projects active in shot SMOKY are listed in Table 3-1, including the organizations under AFSWP responsible for each project.

From one shot to another, project personnel and supervisory AFSWP staff personnel worked at various tasks throughout the Nevada Test Site. In doing their work--layout, construction, installation, dry run, operation, and recovery of data or instruments--personnel could have passed through or worked in areas with measurable low-level radiation from previous events which had only incidental relationship to SMOKY. A detailed scenario of DOD personnel activities in the presence of radioactive contamination has not been found which will permit allocation of dose readings on individual film badges entirely to any particular shot.* Since AFSWP functioned as part of the NTO, all Rad-safe services were provided by REECo, and all activities in the forward areas were subject to NTO Rad-safe and security procedures. AFSWC (4926th Test Squadron) provided Rad-safe support for AFSWP aircraft used in these activities. The following subsections describe the specific AFSWP technical projects which were conducted during SMOKY and were carried out by the Field Command Weapons Test group.

Project 1.8 (Effects of Rough and Sloping Terrain on Airblast Phenomena). This was conducted solely at SMOKY and had three objectives:

- To investigate the blast damage sustained by drag-sensitive targets
- To determine the effect of rolling, steep slopes and rough terrain on nuclear blast wave parameters
- To provide blast wave measurements.

The responsibility for actually accomplishing Project 1.8 rested with the U.S. Army's Ballistic Research Laboratories and the Stanford Research Institute (5;6). Its objectives required personnel to place vehicles and

*A name-by-name analysis of REECo dosimetry records can provide some of this information.

Table 3-1. AFSWP PROGRAMS AT SHOT SMOKY.

Project	Title	Conducted By	Estimated DOD Personnel
1.8	*Effects of Rough and Sloping Terrain on Airblast Phenomena*	Ballistic Research Laboratories (BRL); Stanford Research Institute (SRI)	BRL: 69 SRI: 19
1.9	Spectra of Ground Shocks Produced by Nuclear Detonations	Air Research and Development Command; Ramo-Woolridge Corp.	10
2.3	Neutron Flux from Selected Nuclear Devices	AFSWP/U.S. Army Chemical Warfare Laboratories	9
4.3	Secondary Missiles Generated by Nuclear-produced Blast Waves	Lovelace Foundation for Medical Education and Research; CETG Project 33.2 Personnel	14
5.3	In-flight Structural Response of the FJ-4 Aircraft to a Nuclear Detonation	U.S. Navy Bureau of Aeronautics; North American Aviation, Inc.	1
5.4	In-flight Structural Response of the A4D-1 Aircraft to a Nuclear Detonation	Douglas Aircraft Company; U.S. Navy Bureau of Aeronautics	2
5.5	In-flight Structural Response of the F-89D Aircraft to a Nuclear Detonation	Wright Air Development Center (WADC); Northrop Aircraft, Inc.	2
6.4	*Accuracy and Reliability of the Short-baseline* NAROL System	Air Force Cambridge Research Center	2
8.3b	Instrumentation for Measuring Effects Phenomena Inside the Fireball	WADC; University of Dayton Research Institute, Allied Research Associates	WADC, 82; Univ. of Dayton, 8; Allied Research, 2
9.1	Support Photography	Military Air Transport System, AFSWC; AFSWP Photographers	8

instruments at various locations around ground zero, as shown in Figure 3-1. Fifty-one jeeps and two M-48 tanks were placed at various locations in order to accomplish the first objective, that of investigating the blast damage sustained by drag-sensitive targets. This project was related to Desert Rock Project 50.7, which, at SMOKY, involved only the M-48 tanks. (Project 50.7 was discussed in Chapter Two.) In order to accomplish further objectives, personnel placed self-recording, electronic gauges along five blast lines. Figure 3-1 shows the layout of the lines relative to vehicle placement and ground zero. Table 3-2 shows how many of the various types of gauges were used along the blast lines and on the jeeps. Post-shot project personnel made an evaluation which consisted of an inspection of the damages sustained by each vehicle and the recording of the vehicle displacement and orientation. The vehicles and gauges were then removed.

Table 3-2. GAUGES FIELDED FOR PROJECT 1.8.

Gauges	Blast Line No.						
	1	2	3	4	5	Jeeps	Totals
Pressure-Time	38	16	12	16	20	18	120
Dynamic Pressure	10	18	12	18	–	2	60
Pitch	6	–	8	0	0	0	14
Total	54	34	32	34	20	20	194

Project 1.9 (Spectra of Ground Shocks Produced by Nuclear Detonations). The project objective was to obtain the displacement, velocity, and acceleration-shock spectra of ground shocks produced by nuclear devices (13). The measured data on ground shocks were to be used in the design of missile bases and operational equipment which could withstand a nuclear environment. The responsibility for accomplishing Project 1.9 rested with the Air Force Ballistic Missile Division.* For shot SMOKY, five shock gauges and protecting canisters

*Since Project 1.9 was conducted at other PLUMBBOB shots in addition to SMOKY, an account of the activities required to install the gauges for this project, as well as a description of the gauges themselves, is given in the PLUMBBOB series volume.

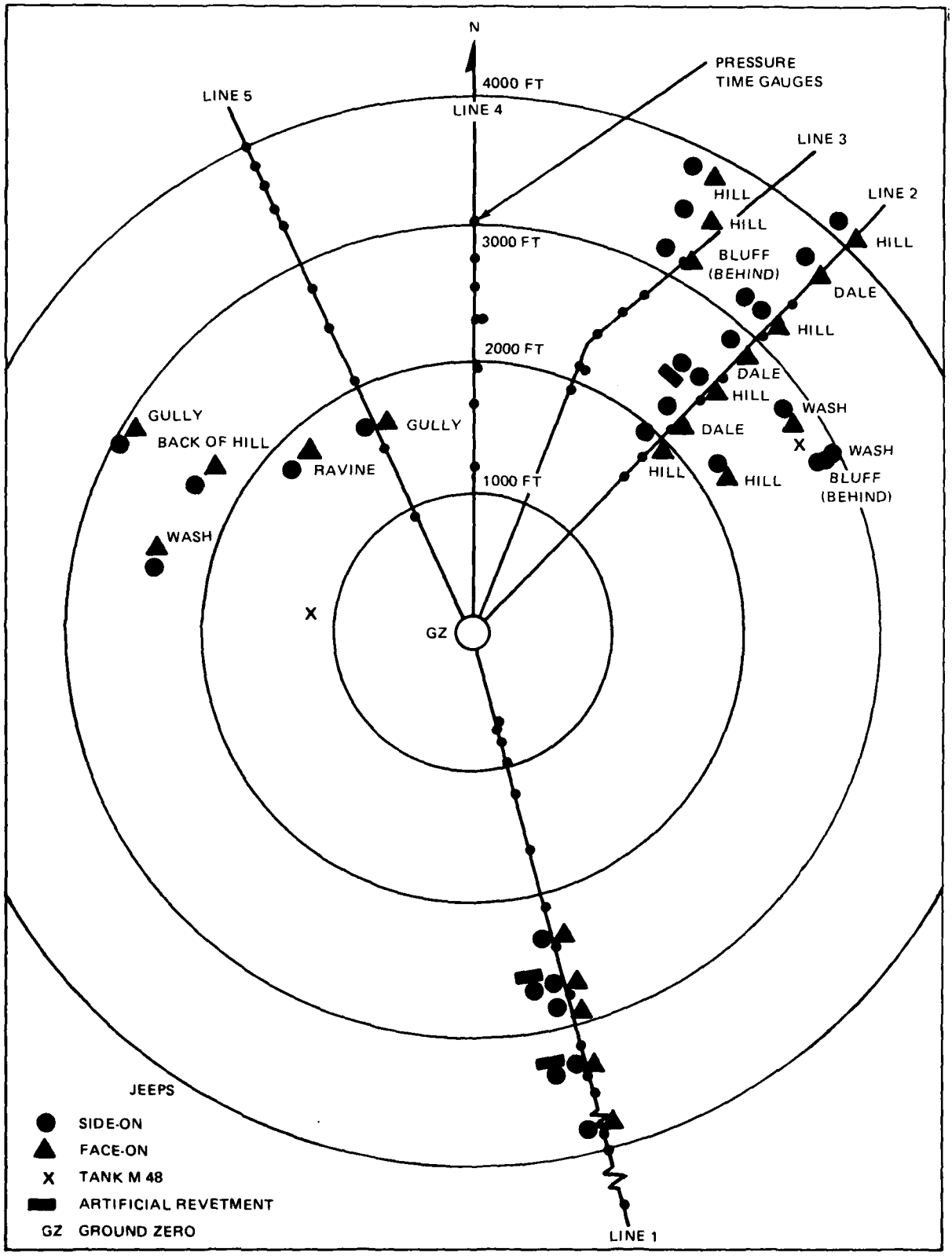

Figure 3-1. LAYOUT FOR BLAST LINES AND VEHICLES.

were used. The gauges were placed at locations predicted to receive 116 pounds per-square-inch overpressure. Three gauges were placed directly on the ground while the other two were affixed by means of anchor bolts to the floor of a German-designed field shelter. These sheltered gauges were further protected by a layer of at least three thicknesses of sandbags. The records were recovered post-shot, and the canisters and gauges were removed for use on other events.

Project 2.3 (Neutron Flux From Selected Nuclear Devices) (29). The objectives of Project 2.3 were as follows:

- To measure the neutron flux versus ground range for a nuclear device
- To determine the effect of terrain on the neutron flux.

The responsibility for accomplishing Project 2.3 rested with the U.S. Army Chemical Warfare Laboratories, who cooperated with the Civil Effects Test Group for SMOKY. Instrumentation was installed along three cable lines at various azimuths (see Figure 3-2)*:

- One line south from ground zero along level terrain
- One line north from ground zero and over a 500-foot hill
- One line northeast from ground zero and over hilly terrain.

For SMOKY, 300 of these detectors were placed at 39 different locations on the three cable lines. Because of the high fallout contamination, personnel were unable to recover some of the detectors until H+72 hours. At that time, gamma decay measurements taken for each sample were extrapolated to H+20 hours by superimposing these curves onto a calibration curve. The neutron flux, spectra, and dose data obtained along the three lines were inconclusive because of the unknown effects of the complex shielding surrounding the device. Following the shot, the three cables were pulled out of the surrounding high radiation field by

*The three lines were instrumented with the various neutron detectors described in detail in the PLUMBBOB series volume.

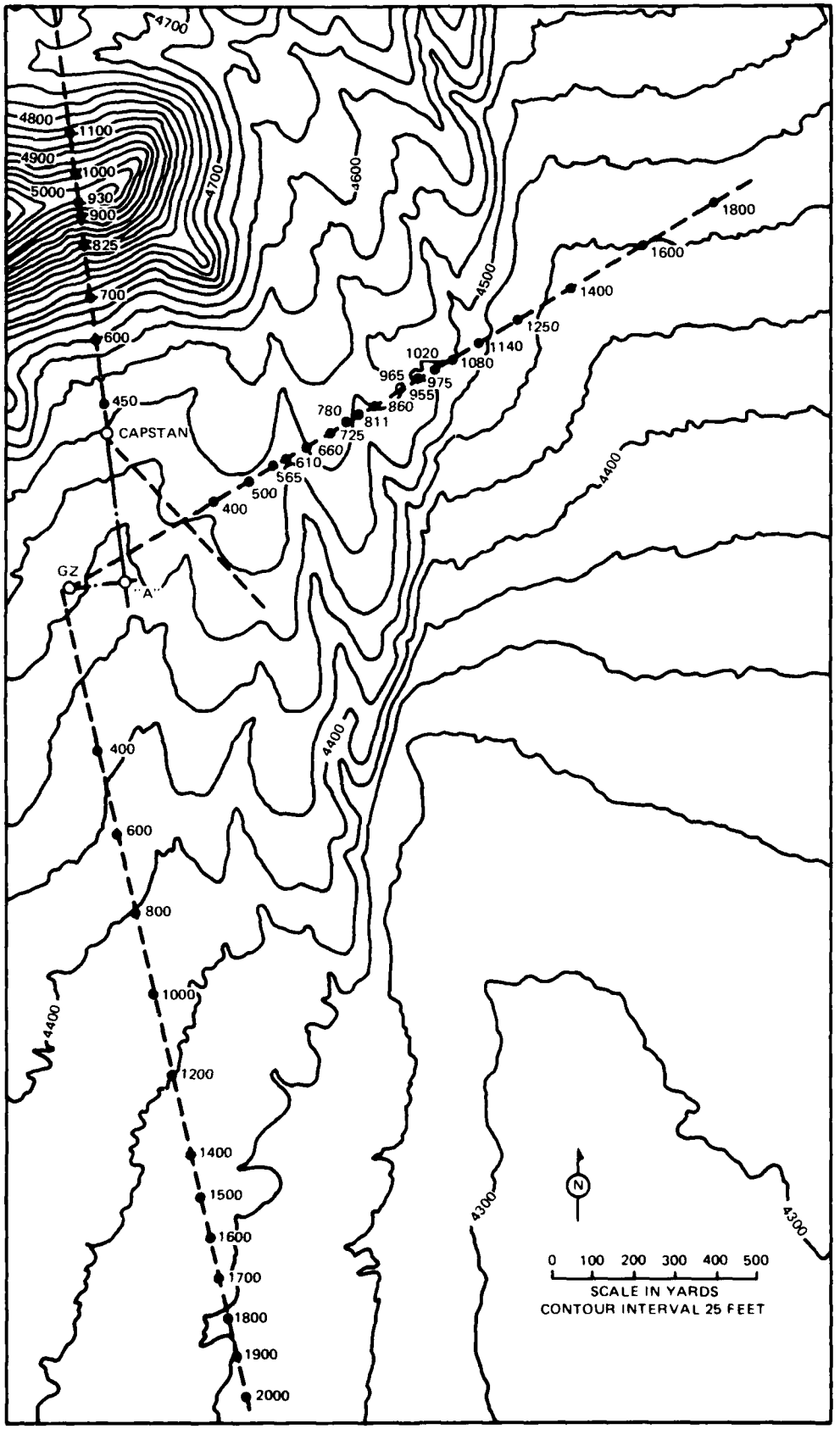

Figure 3-2. TOPOGRAPHIC VIEW OF PROJECT 2.3 STATION LOCATIONS, SHOT SMOKY.

tractor and truck while personnel were unfastening the detectors from the cables. The detectors were then returned to the laboratory trailer, which was located near CP-1, where the samples were removed from the holders and evaluated. REECo mentions two cable recovery operations which followed shot SMOKY (7). Entry into the forward area for both operations began at H+5 minutes, and activities continued there about 1 1/2 hours. Both recovery operations used tractor and truck drivers. One of the operations consisted of a party of four individuals, including one REECo laborer who went to an area 3,400 feet east of ground zero. The second party, made up of five persons including two REECo laborers, went to an area 4,000 feet northeast of ground zero. Pocket dosimeter readings of 1,245, 395, and 270 mR are shown for three of the individuals who participated in these operations. (Further details about the results of Project 2.3 are given in Chapter 4 under the section on radiological environment.)

Project 4.3 (Secondary Missiles Generated by Nuclear-Produced Blast Waves)(4).* This project was partially funded and coordinated with the Department of Defense. It was administered by the Civil Effects Test Group and is documented as CETG Project 33.2 (23a). Participation in shot SMOKY was to determine the effects of hill-and-dale terrain on the blast-produced missiles which would be of value in assessing secondary (those due to hazards caused by blast overpressure, winds, or ground shock) type blast injuries. For example, a secondary blast injury is caused by flying objects such as rocks, building materials, or tree limbs.

In shot SMOKY, the translation of native (or natural) stones, steel spheres, and military debris was made in open areas at ranges of 2,548 to 5,680 feet, where the measured overpressures varied from about 13 to 5 psi. Locations of the nine stations used in this shot are shown in Figure 3-3; two are on flat terrain on the south blast line, three on hills and three in dales on the northeast line, and one in a dale on the north line. Two trap bases were installed at each station, one base for a single trap and the other for two traps. A total of 405 steel spheres with diameters of 7/16, 1/2, and 9/16 inches was placed at various distances in front of the traps. In addition, about 3,850

*Because this project was also conducted on PRISCILLA and GALILEO, the PLUMBBOB series volume contains a general description of this project.

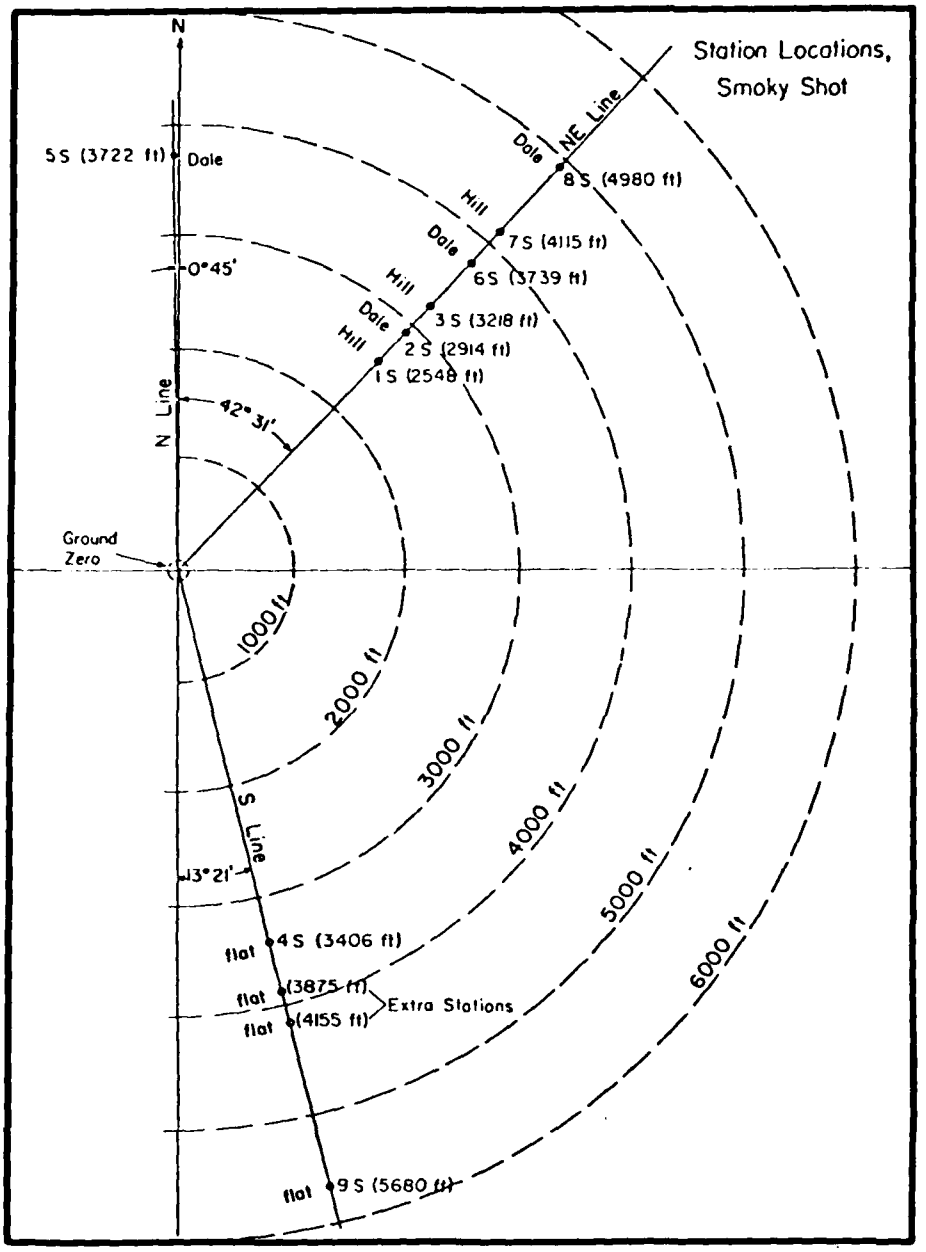

Figure 3-3. STATION LOCATIONS FOR SHOT SMOKY IN AREA 2C, NTS.

pieces of military debris whose masses varied from approximately 1 to 1,000 grams were set out. The spheres were placed a short distance above ground level in a shallow trough supported by 1/8-inch steel rods. Three traps were placed at each of nine stations located on three blast lines. The station nearest to ground zero (1S) had a measured overpressure of about 13 psi and the most distant one (9S) had a measured overpressure of about 5 psi.

Hill-and-dale effects were studied at six stations on the northeast blast line and at one station on the north line. In general, the hill stations (1S, 3S, and 7S) produced missiles with velocities that were higher than those predicted, and the dale stations (2S, 5S, 6S, and 8S), lower than predicted. The effect was particularly noticeable at the dale station (5S) on the north line.

Two stations were placed on the south blast line where the terrain was flat. The blast wave incident at the 3,406-foot station (4S) was significantly modified by surface thermal effects which resulted in higher dynamic pressures and higher missile velocities than expected for an ideal wave. The blast wave that reached the second station on the south line (9S at 5,680 ft) was almost ideal in form, producing natural-stone velocities in good agreement with those predicted. A total 2,876 natural-stone missiles were caught by the 27 traps used in this shot: 34 percent was caught by the lower (a) traps at the installations where the traps were stacked, 41 percent by the upper (b) traps, and only 25 percent by the traps not stacked. About 550 pieces of military debris were placed in front of the traps at each of eight stations. A total of 405 steel spheres (1/16-, 1/2-, and 9/16-inch-diameter steel) was placed at four stations. Only two pieces of military debris and five spheres were recovered.

Project 5.3 (In-flight Structural Response of the FJ-4 Aircraft to a Nuclear Detonation)(16).* This project, conducted by the U.S. Navy Bureau of Aeronautics and North American Aviation, Inc., had three objectives:

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*Because Project 5.3 was conducted throughout PLUMBBOB rather than solely at SMOKY, the PLUMBBOB series volume contains details about instrumentation for SMOKY. Some details about SMOKY are given here, however, in order to determine whether personnel were exposed to radiation.

- To measure thermal and blast response of the FJ-4 aircraft to the effects of a nuclear explosion
- To correlate the experimental response data with analytic predictions in order to confirm the delivery capability of the FJ-4 aircraft
- To obtain data to help improve the methods for predicting the blast response of swept wing aircraft.

The planned flight patterns are shown in Figure 3-4. Two identically instrumented FJ-4 aircraft (one pilot each) participated in shot SMOKY. One of the aircraft was forced to abort when the M-33 radar van used for the project lost the radar lock-on. At the time of the blast, the second aircraft was positioned in a level flight with the tail facing the blast. Figure 3-5 projects the position at shot-time of the aircraft relative to ground zero. Table 3-3 gives the actual position of the FJ-4 at the time of detonation and shock arrival. Table 3-4 gives the atmospheric conditions at shot time, and Table 3-5 gives the flight conditions at the time of detonation and shock arrival.

The nuclear radiation data recorded during Project 5.3 consisted of gamma ray dose measurements, as deduced from the film badges located at four positions in the test aircraft. Table 3-6 shows these measurements, as well as post-shot calculated doses.

Table 3-3. POSITION OF FJ-4 AT TIME OF BURST AND SHOCK ARRIVAL.

	Altitude Above Burst (ft)	Horizontal Distance (ft)	Slant Range (ft)	Angle of Incidence Above Horizontal (deg)
Time of Burst:	9,992	+7,513	12,502	53.05
Time of Shock Arrival:	10,024	+20,436	22,762	26.13

+Beyond Ground Zero

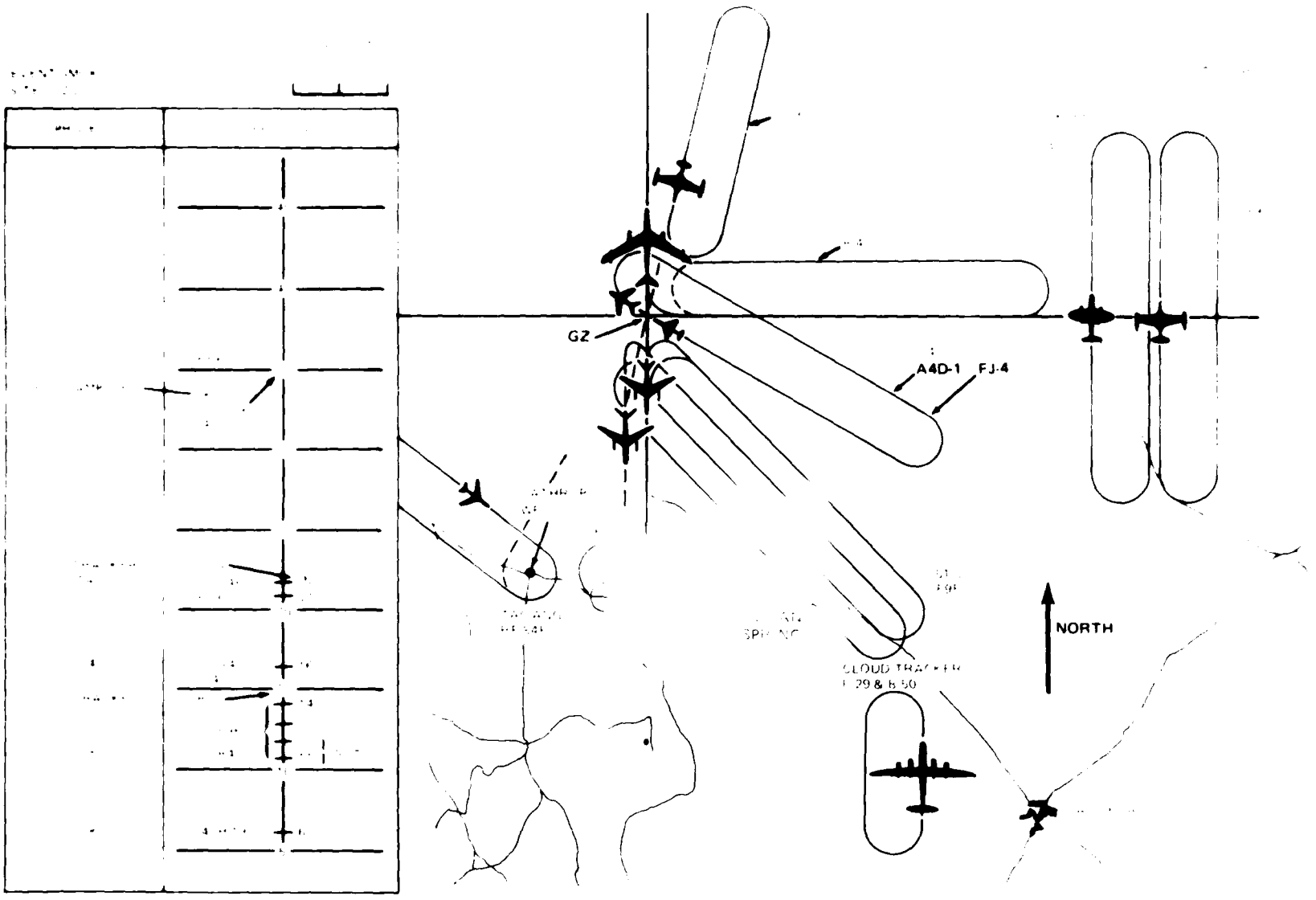

Figure 3-4. PLANNED FLIGHT PATTERN FOR AIRCRAFT PARTICIPATING AT SMOKY.

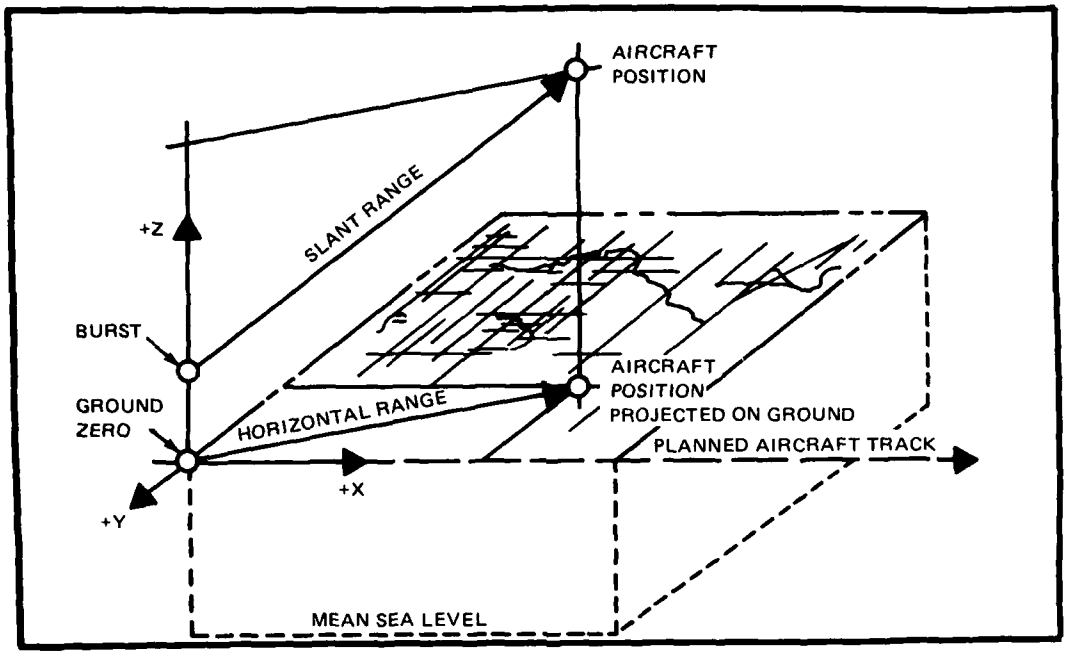

Figure 3-5. PROJECTED POSITION AT SHOT TIME OF FJ-4 AIRCRAFT RELATIVE TO GROUND ZERO.

Table 3-4. ATMOSPHERIC CONDITIONS AT SHOT TIME FOR FJ-4.

Pressure at Ground Zero, mbar	856
Pressure at Flight Altitude, mbar	580
Temperature at Ground Zero, °F	57
Temperature at Flight Altitude, °F	20
Density at Flight Altitude, slugs/ft^3	0.001469
Speed of Sound at Flight Altitude, ft/sec	1074
Humidity at Ground Zero, pct	31
Humidity at Flight Altitude, pct	NA*
Low Clouds, Coverage Type	None
Medium Clouds, Coverage Type	None
High Clouds, Coverage Type	None

* Data not available.

Table 3-5. FLIGHT CONDITIONS FOR FJ-4 AT TIME OF BURST AND SHOCK ARRIVAL.

	True Airspeed (ft/sec)	Mach Number	Angle of Pitch (deg)	Gross Weight (lb)	Angle of Attack (deg)
Time of Burst:	733	0.679	-1.5	–	–
Time of Shock Arrival:	739	0.682	–	18,609	NA *

* Data not available.

Table 3-6. GAMMA RAY MEASURED AND CALCULATED DOSE AT FOUR POSITIONS IN THE TEST AIRCRAFT.

Measured Gamma Dose					Post-Shot Calculated Gamma Dose	Post-Shot Calculated Total Dose	Shielding of Shot
Cockpit *	Cockpit †	Right Wing Tank	Ammo Bay	Wheel Well			
R	R	R	R	R	R	rem	R
0.71	0.35	1.30	1.30	1.00‡	1.15	1.25	None

* Left side of pilot's seat.
† Aft of pilot's right shoulder.
‡ Externally mounted on left tank.

The aircraft were staged out of Indian Springs Air Force Base, 15 to 20 road miles from the Nevada Test Site. The 4926th Test Squadron provided Rad-safe support for all aircraft based at Indian Springs (16).

Project 5.4 (In-flight Structural Response of the Model A4D-1 Aircraft to a Nuclear Detonation)(36). This was conducted by Douglas Aircraft Company and had three objectives:

- To measure the thermal and blast gust response of the A4D-1 aircraft to the effects of a nuclear detonation.
- To obtain data to improve the methods of predicting the blast gust response of aircraft with triangular wings
- To correlate the experimental response data for the A4D-1 with analytical methods in order to determine the aircraft's nuclear weapon delivery capability.

Although the A4D-1 (one pilot each) aircraft were instrumented for SMOKY, only one participated; the other aircraft was kept in reserve in case of engine failure in the first.* The planned flight pattern is shown in Figure 3-4. For shot SMOKY, the A4D-1 was flown on a straight and level course directly over ground zero. Positioned outside the triple-point path from the detonation, the aircraft received the gust from the detonation at an angle of 31 degrees to the fuselage reference line. Tables 3-7 through 3-10 provide specifics on this A4D-1 project.

Table 3-7. A4D-1 POSITION AT TIME OF DETONATION.

Airplane Number	137831
Slant Range	11,858 feet
Horizontal Range	5,156 feet
Altitude Above Burst	10,678 feet
Altitude Above Terrain	11,378 feet
Altitude Above Mean Sea Level	15,857 feet

*The PLUMBBOB series volume contains details about the instrumentation.

Table 3-8. A4D-1 POSITION AT TIME OF SHOCK ARRIVAL.

Time of First Shock Wave	15.70 seconds
Slant Range	20,386 feet
Horizontal Range	17,404 feet
Altitude Above Burst	10,615 feet
Altitude Above Terrain	11,315 feet
Altitude Above Mean Sea Level	15,784 feet
X Distance	*
Y Distance	*
Time of Second Shock Wave	
Slant Range	†

* Data not available.
† Airplane beyond triple-point path.

Since the aircraft was staged out of Indian Springs Air Force Base, the 4926th Test Squadron provided Rad-safe support and decontamination.

Table 3-9. FLIGHT AND ENVIRONMENTAL PARAMETERS AT TIME OF SHOCK ARRIVAL AT A4D-1.

Pressure Altitude	15,400 feet
Ambient Air Temperature	482°R
True Airspeed	421 knots
True Airspeed	711 ft/sec
Mach Number	0.661
Ambient Pressure	1,175 psf
Ambient Speed of Sound	1,075 ft/sec
Density	$x10^{-3}$ slugs/ft^3
Airplane Weight	12,300 lb

Data apply to arrival of first, second, and third shock wave. After first shock wave pressure-sensitive instruments are unreliable.

Table 3-10. NUCLEAR RADIATION DATA RECORDED ON A4D-1.

Nuclear Radiation Data (rem) *

Cockpit dosimeters	Dose (rem)	Cockpit film badges
1	†	1
2	†	2
3	1.5	3
4	1.1	4
5	1.0	5
		6

Airplane dosimeters	Dose (rem)	Airplane film badges
6	†	7
7	†	8
8	1.6	9
9	1.7	10
10	1.7	

* **Calculated dose based on aircraft film badges equals 2.85 rem.**

† **Data not measured.**

Project 5.5 (In-flight Structural Response of an F-89D Aircraft to a Nuclear Detonation)(1). This project was conducted by Northrop Aircraft, Inc. and Wright Air Development Center. The primary objective of this project was to determine the structural response of the F-89D aircraft in flight to the blast and thermal effects of a nuclear detonation. A secondary objective was providing basic research data for use in the design of future United States Air Force aircraft. The planned flight pattern is shown in Figure 3-4. For shot SMOKY, this project employed an F-89D aircraft (with two crew members) as the test vehicle.* The aircraft approached ground zero at an airspeed of Mach 0.85. At shock arrival, it was flying in a steady-state 1.0g level flight condition. Table 3-11 gives the position of the F-89D at both shot time and shock arrival time.

Table 3-11. THE POSITION OF THE F-89D AT SHOT TIME AND SHOCK ARRIVAL TIME.

Altitude True		Horizontal Range		Offset + = Right - = Left		Slant Range		Wing Angle of Attack Nose-up, Degrees from	Angle Between Horizontal Receiver and Line to Burst	
Desired	Measured	Desired	Measured	Desired	Measured	Desired	Measured	Horizontal	Predicted	Measured
(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(deg)	(deg)	(deg)
Aircraft Position at Time Zero:										
20,000	20,100	-48,520	-48,820	0	750	50,730	51,050	1.10	17.0	17.0
Aircraft Position at Shock Arrival:										
20,000	20,100	-26,330	-26,510	0	+750	30,120	30,430	1.10	29.3	29.4

For the aircrew participating at SMOKY, the radiation exposure limit was 5 rem (as approved by the AEC Test Manager). In this project, neither the pilot nor the observer received radiation exposure at SMOKY, and the aircraft was not contaminated.

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*The details of the instrumentation are given in the PLUMBBOB series volume.

Project 6.4 (Accuracy and Reliability of the Short-baseline NAROL System)(15).* Air Force Cambridge Research Center conducted this project whose objectives were:

- To determine the position and yield of a nuclear detonation as a function of distance from ground zero
- To investigate methods for isolating the electromagnetic pulse of a nuclear detonation from lightning transients
- To collect data on the nature of bomb pulse distortion which results from overland propagation.

For shot SMOKY specifically, an area gating system was incorporated into the equipment. This system alerted its operators to analyze any electromagnetic pulse originating within a specific target area. The NAROL nets were located 500 and 850 miles from the Nevada Test Site. Since Project 6.4 personnel were so far from the NTS, no one participating in this project received measurable radiation exposures.

Project 8.3b (Instrumentation for Measuring Effects Phenomena Inside the Fireball)(8). This project involved three groups: Wright Air Development Center, University of Dayton Research Institute, and Allied Research Associates, Inc. Its objectives were:

- To instrument tests for future use in making measurements within the fireballs resulting from nuclear detonations
- To increase the information available regarding the thermonuclear effects of a nuclear detonation
- To measure the time history of the pressure, acceleration, and temperature of a nuclear detonation
- To determine peak velocities by means of mechanical velocity--distance impact gauges
- To supplement ablation data obtained in previous tests.

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*The PLUMBBOB series volume contains the general description of instrumentation for Project 6.4.

Project 8.3b was active only during shot PRISCILLA and shot SMOKY. During SMOKY, 23 specimens were exposed within the fireball, and one at a greater range was exposed to neutron bombardment only. The cable supporting system is shown in Figure 3-6. Three specimens contained electrical instrumentation. Twenty specimens were located at the desired slant ranges by suspending them from cables extending from the floor of the cab to deadman anchors in the ground. Two specimens were mounted on the shot tower, and a graphite sphere was located on the ground. After the detonations, the specimens were recovered and analyzed to determine the degree and type of damage. The instrumentation used to record the data for the experiments of Project 8.3b is shown in Table 3-12.

The experiments themselves consisted of electrical, mechanical, and passive-instrumented specimens. The electrically instrumented specimens were designed in an attempt to measure (1) the specimen velocity as a function of distance traveled, (2) the peak overpressure, and (3) the peak temperature. In addition, an experimental electrical-mechanical scratch gauge was used in an attempt to measure how far the specimen traveled as a function of time. The passive specimens were exposed during this operation in order to supplement ablation data obtained from previous tests and to study the physical phenomena associated with the ablation of different materials. The passive specimens included eight solid spheres of different materials and six items containing inserts of different materials.

The activities for Project 8.3b at SMOKY began on 15 August 1957. At that time, all cables with specimens or with weights simulating the specimens were raised into position in order to check the effects on instrumentation in the cab. Accidental slippage of specimens necessitated some unplanned operations in the area to restructure the experiments. As a result of these accidents, safety slings were made and installed on most of the specimens. Two days before the shot, project personnel had to re-enter the area to examine a zinc sphere found lying on the ground. Because of a lack of time, the sphere was not replaced on the cable. Recovery attempts on 3 and 6 September were unsuccessful because of the high radiation levels. During a preliminary recovery effort, from 8 to 13 October, eight spheres and the electrically-instrumented steel cylinder were recovered, and the locations of the specimens were staked. All of the recovered specimens were moved to the storage area for radioactive materials because their surface readings were from 300 to 1,600 mR/h. From 8 to 10 January 1958, five

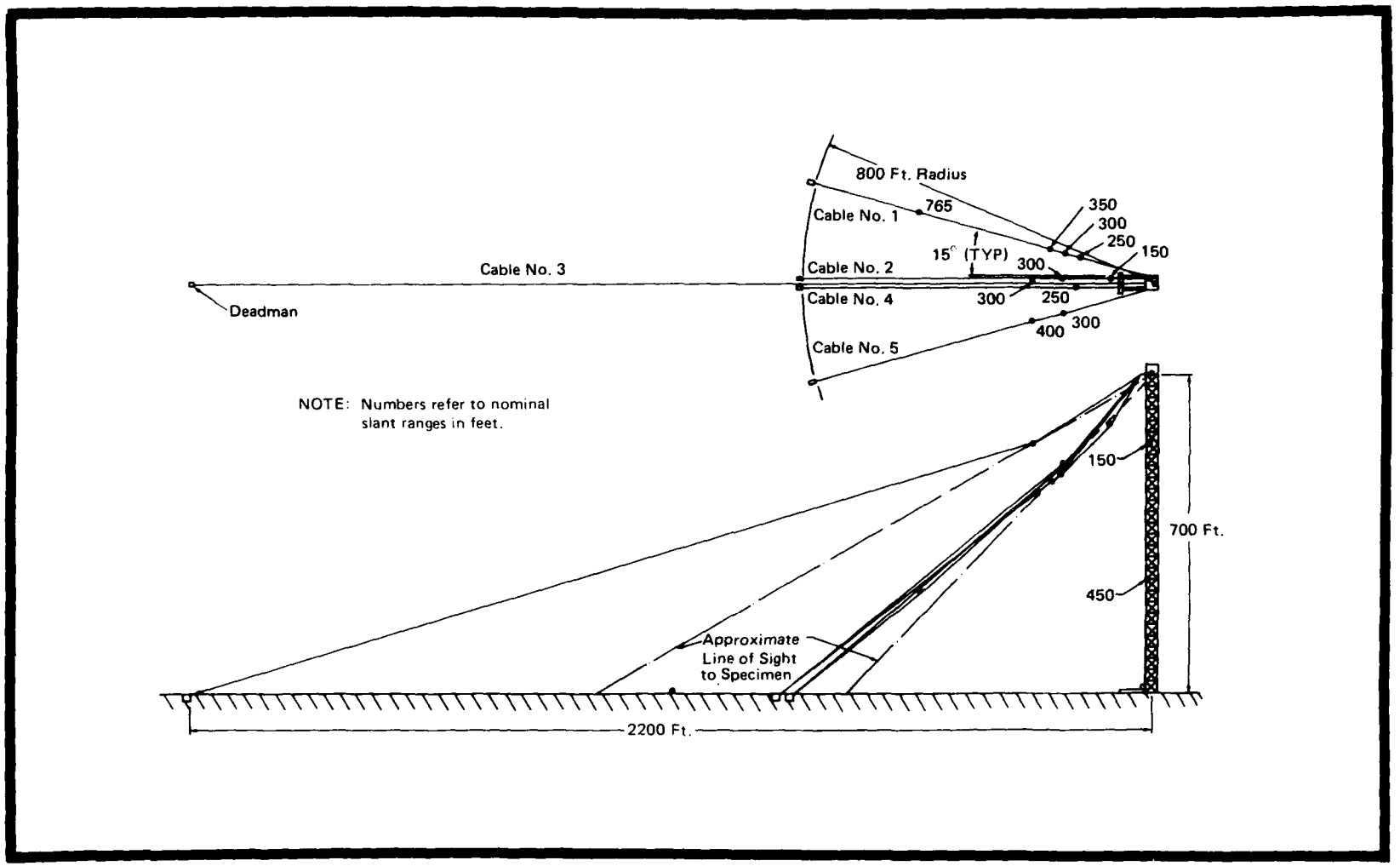

Figure 3-6. EXPOSURE TECHNIQUE FOR SPECIMENS, SHOT SMOKY.

Table 3-12. PROJECT 8.3b SPECIMEN INFORMATION.

Specimen	Diameter (inches)	Weight (pounds)	Instrumentation	Location
MI Steel Sphere (Type 2)	13	318	Peak pressure, inserts and intensity gauges	Cable 2
Insert Sphere	13.44	320	Inserts and intensity gauges	Cable 2
MI Sphere (Type 20)	13.44	230	Velocity-distance	Cable 2
EI Cylinder	15 (7 feet long)	2,300	Two tape recorders peak pressure and velocity-distance	Tower
EI Steel Sphere (Type 2)	13.44	247	One tape recorder and velocity-distance	Cable 4
MI Steel Sphere (Type 3)	13	318	Peak pressure-inserts and intensity gauges	Cable 4
Insert Sphere	13.44	321	Inserts and intensity gauges	Cable 4
MI Bowling Ball	5	4	Intensity gauge and inserts	Cable 1
Iron Sphere	10	149	--	Cable 5
Zinc Insert Sphere	10	135	--	Cable 5
Titanium Sphere	8	44	--	Cable 5
Molybdenum Sphere	8	99	--	Cable 2
Stainless Steel Sphere	8	74	--	Cable 1
Copper Sphere	8	87	--	Cable 5
Plastic Sphere 91LD	8	17	--	Cable 3
EI Steel Sphere (Type 3)	13.44	247	One tape recorder and velocity-distance	Cable 1
MI Steel Sphere (Type 4)	13	318	Peak pressure, inserts and intensity gauges	Cable 1
Insert Sphere	13.44	320	Inserts and intensity gauges	Cable 1
Zinc Sphere	10	135	--	Cable 5
Zinc Insert Sphere	10	133	--	Cable 5
MI Bowling Ball	5	4	Intensity gauge and inserts	Cable 5
Insert Cylinder	8 (40 inches long)	366	Inserts	Tower
MI Sphere (Type 50)	13.44	38	Velocity-distance	Cable 1
Graphite Sphere	8	17	--	Ground

additional specimens were located. These specimens were staked, but no attempt was made to remove them from the area. On 24 January, after the level of radiation in the general impact area had decayed to approximately 400 mR/h, project personnel returned to the test site and attempted to recover the remaining specimens. On subsequent days, personnel found the insert cylinder, graphite sphere, and several pieces of the plastic sphere. Except for the graphite sphere, which was buried, all these specimens were on top of the ground. The specimen and crater locations were surveyed with respect to the shot tower. Recovery operations ended on 1 February 1958.

Project 9.1 (Support Photography). This program was primarily of a support nature and consisted of the following tasks (33):

- To support technical photographs of the military effects programs
- To document the overall program and produce a military effects motion picture
- To document the detonations for release through the Joint Office of Test Information
- To provide general photographic support of the Department of Defense (DOD) projects for historical purposes.

For purposes of technical photographic support, Program 9.1 provided camera instrumentation for Project 1.8. Both color coverage and black-and-white coverage of the SMOKY detonation were done from an airborne camera station and a forward-area manned camera station. This coverage consisted of still and motion picture photography. The aerial photography aircraft, a C-47 from Orlando AFB, was provided by the Military Air Transport System. The aircraft was staged out of Indian Springs AFB and received Rad-safe support from the 4926th Test Squadron (23).

3.2 DEPARTMENT OF DEFENSE PARTICIPATION IN LOS ALAMOS SCIENTIFIC LABORATORY TEST GROUP PROJECTS

The Los Alamos Scientific ›ry (LASL) performed four projects at shot SMOKY, although only two inv DOD personnel. Table 3-13 lists DOD participants, as well as sponsor and DOD agency associated with each project.

Table 3-13. LASL, UCRL AND SANDIA PROJECTS AT SHOT SMOKY.

Project	Title	Conducted By	Estimated DOD Personnel	DOD Agency
11.1	Radiochemistry Analysis	LASL	None	
11.2	**Radiochemistry Sampling**	**LASL**	**2**	**4926th Test Squadron, AFSWC**
16.2	**Temperature Measurements—Portable Recorder**	**LASL/ EG&G**	**5***	
17.1	Electromagnetic Measurements	LASL	None	
21.1	Radiochemistry Analysis	UCRL	None	
21.2	**Radiochemistry Sampling**	**UCRL**	**10**	**AFSWC**
21.3	**Rocket Sampling**	**UCRL**	**3**	**AFSWC**
22.1	Nuclear Radiation Measurements	UCRL	None	
22.2	Remote Technique Development	UCRL	None	
22.3	Telemetry	UCRL	None	
22.4	Development Experiments	UCRL	None	
23.1	Flow and Capacity	UCRL	None	
23.3	Ball of Fire and Bhangmeter	UCRL/ EG&G	None	
23.4	Cloud Photography	UCRL/ EG&G	None	
64.2	High Time Resolution Telemetry	Sandia	None	
64.3	Neutron Sources	Sandia	None	

* Onsite.
NOTE: Bold Print Indicates Projects with DOD Participation.

Project 11.2, (Radiochemistry Sampling), was sponsored jointly by LASL and The University of California Radiation Laboratory (UCRL). AFSWC's 4926th Test Squadron performed cloud sampling for UCRL and Project 53.1 personnel; U.S. National Guard aircraft on training missions collected samples for LASL. Analyses were done at both UCRL and LASL for yield determination. The 4926th Test Squadron maintained a Nuclear Applications Section, whose primary function was to instrument and prepare aircraft for nuclear cloud sampling. This section was also responsible for removing the cloud samples from the aircraft and preparing them for analysis. In addition, the Nuclear Applications Section operated decontamination and personnel dosimetry facilities (See Chapter 4, Section 4.7.1 for a description of AFSWC sampling facilities).

Project 16.2 (Portable Recorder-Temperature Measurements), was performed for LASL by EG&G, according to the LASL J-16 letter reports. Information was obtained from the EG&G bhangmeter station at the CP, which recorded at all events. Additionally, station locations varied from the CP to Kingman, Arizona; Los Alamos, New Mexico; and other remote areas. Personnel participating in Project 16.2 operating the telemetry equipment were military, but the total number of DOD participants is unknown.

3.3 DEPARTMENT OF DEFENSE PARTICIPATION IN THE UNIVERSITY OF CALIFORNIA RADIATION LABORATORY TEST GROUP PROJECTS

The UCRL Test Group conducted twelve projects at shot SMOKY, either as the sole sponsor or in conjunction with another agency. Only Program 21 involved DOD participants. All projects are listed in Table 3-13.

Program 21 consisted of two projects involving DOD personnel: 21.2 and 21.3 (Radiochemistry Sampling and Rocket Sampling). This program had the same objective as the LASL Program 11, which was to determine the yield of the device. The procedures in Project 21.2 were exactly the same as for LASL, except that sample measurements were done at UCRL, rather than at LASL. Program 21 required no ground recovery near ground zero.

3.4 DEPARTMENT OF DEFENSE PARTICIPATION IN CIVIL EFFECTS TEST GROUP PROJECTS

This section describes DOD involvement in Civil Effects Test Group Projects at SMOKY, some of which were conducted in conjunction with the Federal Civil Defense Administration, the Lovelace Foundation for Medical Education and Research, and the Sandia Corporation. The CETG conducted 22 projects at SMOKY, which are shown in Table 3-14. Those projects involving DOD participation are summarized below.

Project 30.5 (Shelter and Structure Blast Instrumentation). The objective of this project was to provide electronic and self-recording instrumentation for shock loading and response measurements for various structures of Programs 30 and 31. It specifically provided loading and response for Projects 30.6 and 30.7. Project 30.5 involved Ballistics Research Laboratory participation.

Project 33.2 (Missiles Secondary to Nuclear Blast) was designed to determine the size, weight, and velocity of artificial and natural objects (steel fragments, gravel, etc.) that could be propelled by the blast wave from a nuclear detonation. It was partially funded, however, by the Field Command Weapons Effects Test Group as its Project 4.3 (Secondary Missiles Generated by a Nuclear Detonation.) Field Command also provided minor logistical support to the Civil Effects Test Group for this project. No DOD personnel appear to have taken part in project activities in the forward area.

Project 33.3 (Displacement Potential of Blast). The objective of this project was to observe, by means of high-speed photography, the displacement of human-like dummies and spheres across a stabilized area suitably marked as a reference grid and to extrapolate these data to blast phenomena which can translate large bodies from a static to dynamic state. Pressured readings were obtained from Project 33.2. Cameras with a time reference covered the stabilized area.

Table 3-14. CETG PROJECTS CONDUCTED AT SHOT SMOKY.

Project	Title	Conducted By	Estimated DOD Personnel	Performing Agency
30.5	**Shelter and Structure Blast Instrumentation**	**FCDA**	**6**	**BRL**
30.6	Structural Test-French Shelters	FCDA/French Govt.	None	Amman and Whitney
30.7	Structural Test-German Shelters	FCDA/West German Govt.	None	Amman and Whitney
31.1	Thermal Activated Air-Zero Locators	FCDA	None	FCDA; National Bureau of Standards (NBS); Eastman Kodak
33.2	**Missiles Secondary to Nuclear Blast**	**DBM/AFSWP/ FCDA**	**14**	**Lovelace Foundation**
33.3	**Displacement Potential of Blast**	**DBM/FCDA**	**14**	**Lovelace Foundation**
34.2	**Comparison Tests of Reinforcing Steels**	**AEC**	**1**	**Sandia Corporation**
34.3	**Comparative Responses of Static and Dynamic Loadings**	**AEC**	**1**	**Sandia Corporation; Holmes and Narver**
35.2	Decontamination Procedures in Residential Areas	FCDA	None	FCDA
35.3	Radiological Defense Monitoring Techniques	DBM	None	FCDA
36.1	Field Radiological Defense Technical Operations	FCDA	None	FCDA
37.1	Biological Accumulation of Fission Products Fallout	DBM	None	Atomic Energy Project/ Univ. of CA Los Angeles (AEP/UCLA)
37.2	**Biophysical Aspects of Fallout Phenomonology**	**DBM**	**3**	**AEP/UCLA**
37.2a	**Identification and Documentation—Physical Aspects of Fallout**	**AEC**	**3**	**AEP/UCLA**
37.4	**Measurement of Fast Neutron Doses by Germanium Dosimeters**	**DBM**	**6**	**AEP/UCLA**
37.5	**Measurement of Ionizing Radiation by Chemical Methods**	**DBM**	**6**	**AEP/UCLA**
37.6	**Application of Radio-Ecological Techniques**	**DBM**	**9**	**Oak Ridge Institute of Nuclear Studies; Dept. of Agriculture; AEP; DOD**
39.1	**Gamma and Neutron Radiation Measurements**	**DBM**	**22**	**NBS; AEC**
39.1a	**Gamma Dosimetry by Film-Badge Techniques**	**DBM**	**22**	**NBS; AEC**
39.1b	**Neutron Dosimetry by the Threshold-Detector Technique**	**DBM**	**22**	**NBS; AEC**
39.5	**Radiation Dosimetry for Human Exposures**	**DBM**	**22**	**Oak Ridge National Lab; USAF School of Medicine**
39.9	**Remote Radiological Monitoring**	**AEC**	**22**	**AEC; USAF School of Medicine**

NOTE: Bold Print Indicates Projects with DOD Participation.

Project 34.2 (Comparison Tests of Reinforcing Steels). The objective of this project was to determine the relative merits of rail- and intermediate-grade steel as reinforcement for concrete beams subjected to the blast loading.

Project 34.3 (Comparative Responses of Static and Dynamic Loadings). The objective of this project was to obtain data on the resistance of buried corrugated metal pipe to high overpressure.

Program 37 (Radio-ecological Aspects of Nuclear Fallout) included seven projects, six of them (as shown in Table 3-14) fielded at shot SMOKY. These projects were designed to assess the biological hazards associated with radioactive fallout from nuclear detonations. Although DOD participation in several of these projects has been documented and limited participation in all has been suggested, the exact nature and precise levels of participation have not been determined.

Projects 37.2/37.2a (Biophysical Aspects of Fallout Phenomenology; and Identification and Documentation Physical Aspects of Fallout) concerned the delineation and characterization of fallout patterns during the shot. Project 37.2 was conducted by approximately 30 people. Certain specific fission-product analyses were conducted by the Chemical Analysis Group of the Atomic Energy Project, University of California at Los Angeles. The personnel of Project 37.2a consisted of as many as 15 two-person teams responsible for installation, operation, and recovery of sampling and monitoring equipment; it is likely that some DOD personnel may have assisted in these activities. The only documented DOD participation in Projects 37.2 and 37.2a is AFSWC radio-relay support.

Project 37.4 (Measurement of Fast Neutron Doses by Germanium Dosimeters) required laboratory and field tests to determine whether improved knowledge of the characteristics of Germanium dosimeters could be used to increase the accuracy and sensitivity of fast neutron dosage measurements obtained near nuclear detonations. Information is presently unavailable on the number of participants, although it is known that DOD personnel were used for transport activities in Projects 37.4 and 37.5.

Project 37.5 (Measurement of Ionizing Radiation by Chemical Methods). The objective of this project was to study prompt, residual, and fallout radiation

by chemical, film, and threshold detector methods. Special emphasis was placed on determining 1) gamma-ray contamination in mixed neutron-gamma fields; 2) neutron components in mixed residual gamma radiations including shielding components; 3) prompt residual gamma radiations including spectral components; 4) beta-gamma or gamma radiations from fallout to provide integrated exposure values with respect to time and to possibly obtain more data on beta-gamma ratios by employing aqueous, energy-independent tissue-equivalent chemical dosimeters and film packs, and; 5) a reevaluation of prompt neutron and gamma data.

Project 37.6 (Application of Radio-Ecological Techniques). The objective of this project was to train veterinarians in radio-ecological techniques and in field applications of these techniques. Participants were also trained in methods of field-sample collection, laboratory analyses, and the evaluation of data on fallout material collected after several nuclear detonations. Time of arrival and particle size distribution vs. various physical factors were investigated. Nine DBM veterinarians participated in this project at SMOKY.

Project 39.1 (Gamma and Neutron Radiation Measurements). The objective of this program was to utilize film dosimetry techniques for the measurement of gamma radiation from a nuclear detonation. Film dosimeters obtained from EG&G were placed at 100-yard internals from approximately 500-1500 yards from GZ. Specially designed holders protected the film dosimeters from thermal and blast effects accompanying the gamma radiation.

Project 39.1a (Gamma Dosimetry by Film-Badge Techniques). The objective was to ensure that the various CETG projects obtained and documented adequate radiation measurements. This was accomplished by measuring the integrated gamma dose at points along the ground and at various locations in selected structures. In addition, fallout measurements and other special data were supplied to some non-CETG projects.

Project 39.1b (Neutron Dosimetry by the Threshold-Detector Technique) was to furnish neutron dose measurements for other CETG projects in several events. Personnel carrying out this effort were the same as those engaged in work of Project 39.5

Project 39.5 (Remote Dosimetry for Human Exposures). The objective of this project was to make a basic study of the angular distribution of fast neutron and gamma rays to determine the shielding afforded by light frame houses and similar structures. About two weeks prior to the shot, shielding stations (120 collimators and 36 sets of goal posts) and physical dosimetry were set up. Threshold detectors and chemical dosimetry were used.

Project 39.9 (Remote Radiological Monitoring) utilized telemetering techniques for recording radiation data as a supplement to offsite and onsite Rad-safe. The former provided coverage in areas not usually covered by Rad-safe, and the latter provided information needed for early recovery parties.

3.5 AIR OPERATIONAL TRAINING PROJECTS

A number of Air Operational Training Projects were conducted during SMOKY. These tests were staged from Indian Springs AFB and other staging areas. (See Table below).

Table 3-15. AIR OPERATIONAL TRAINING PROJECTS (11).

Project	Title	Conducted By	Type Aircraft	No. Aircraft	Staging Base	No. of DOD Personnel
51.3	Navy Heavy Attack Indoctrination (AJ/A3D)	U.S. Navy Pacific Command	F9F-3*	3	Nas San Diego, CA NAS Whidby Is, WA	3
53.1	Aerial Sampling Missions	Air National Guard/USAF	T-33	4	Indian Springs AFB	8
53.7	Indirect Bomb Damage Assessment (IBDA)	Wright Air Development Command	F89-D	1	Indian Springs AFB	1
53.8	Indirect Bomb Damage Assessment (IBDA)	Strategic Air Command	B-47	2	Indian Springs AFB	4
53.9	Photographic Reconnaissance Training	Tactical Air Command; Air National Guard Tactical Reconnaissance Units	RF-84F	2	Tennessee Air National Guard, George AFB, CA	2

*** See following paragraph.**

Project 51.3 (Navy Heavy Attack Indoctrination (AJ/A3D). The U.S. Navy conducted this project, which provided AJ and A3D combat aircraft crews the opportunity to observe an atomic detonation in the near vicinity of a burst. Aircraft flew on a simulated bomb run, offset from the actual GZ. They then performed an escape maneuver to arrive at a position five miles from GZ, heading 180° true at H-hour. The planned flight pattern was shown in Figure 3-4.

earlier in the PLUMBBOB series, aircraft were staged from the Naval Air Stations at San Diego, California and Whidby Island, Washington. According to the AEC Test Manager's Report three F9F-3 aircraft (one pilot each) were substituted at SMOKY (28) for the AJ2 and A3D aircraft which had flown on shot PRISCILLA. The 4950th Test Group (Nuclear) Final Report lists call signs and altitude assignments for three F9F aircraft at SMOKY (11); these aircraft are included in the Air Mission Summary for shot SMOKY which is part of that report. If the aircraft had staged through Indian Springs AFB, the 4926th Squadron would have provided radiological support, including film badging, monitoring, and decontamination. Conflicting documentation and subsequent interviews with participating pilots indicate these missions may not have been flown.

Project 53.1 (Aerial Sampling Mission). This was a project set up to indoctrinate and train Air National Guard pilots. In conjunction with their training activities, they were assigned to collect samples for radiochemical analysis by LASL and UCRL. Four T-33's were used for the cloud sampling.

Project 53.5 (Air Crew Indoctrination--Early Cloud Penetration).* This project was established to provide an opportunity for Air Defense Command aircrew members and aircraft commanders to observe an atomic detonation in the near vicinity of the burst and to penetrate the nuclear cloud. At SMOKY, five T-33 aircraft were scheduled to participate. However, it was decided to discontinue this project prior to SMOKY execution. Therefore, none of the aircraft actually took part in the shot.

Project 53.7 (Indirect Bomb Damage Assessment--IBDA). This project was intended to evaluate IBDA equipment installed in an F89H aircraft staged at Indian Springs AFB. The planned flight pattern for the single F89H (one pilot) participating in SMOKY is shown in Figure 3-4. The aircraft was about 89 nautical miles from the burst and did not fly through the visible cloud. Radiological safety support for this project was provided by the 4926th Squadron, Indian Springs AFB.

Project 53.8 (Indirect Bomb Damage Assessment--IBDA). Two B-47 aircraft (two crew members each) participated in SMOKY. This project was established to

*A general discussion of this project is in the PLUMBBOB series volume.

test the suitability of IBDA equipment and techniques under simulated bomb drop and actual burst conditions. The aircraft were to be at a heading of 360°, 35 nautical miles short of GZ at H-hour. The planned flight patterns are shown in Figure 3-5. Radiological safety support was provided by the 4926th Squadron, Indian Springs AFB. The aircraft did not fly through the visible cloud.

Project 53.9 (Photographic Reconnaissance Training). This project was established to provide an opportunity for Air National Guard Tactical Crews to observe a nuclear detonation in the near vicinity of a burst and to make a damage assessment photo run over the target. At SMOKY, two RF84F aircraft from the Tennessee Air National Guard participated. Project aircraft were staged out of George AFB, California. The planned flight pattern is shown in Figure 3-4. The pass over GZ was planned to be made at H+10 minutes, at an altitude of 10,000 feet at mean sea level. According to Air Force interviews with participating pilots, the aircraft took off from George AFB and flew to the vicinity of Lathrop Wells (Figure 3-4). There, the aircraft orbited at 20-30,000 feet at MSL. After the detonation, the pilots flew under the mushroom cloud at 3-4,000 feet MSL, at approximately 440 knots, and made one photo-reconnaissance pass, spending only a few minutes in the area of the cloud. Upon return to George AFB, they would taxi to a remote area and be monitored by ground personnel. If no contamination was found, the aircraft would taxi back to the usual parking area. If contamination was discovered, the aircraft would be left in the remote area until repeated monitoring showed the level of contamination to be safe, below 7 mR/h. There is no indication of any film badging for these airmen. One of the pilots interviewed indicated that DT-60 dosimeters were worn as part of the required flight equipment. However, these are high range dosimeters and the readings would probably not be significant. No dose readings have been found for these pilots.

3.6 AFSWC: CLOUD SAMPLING AND TRACKING

In addition to those aircraft necessary to support the numbered projects under Camp Desert Rock, Air Force aircraft also participated in projects designed to sample and track the particulate and gaseous radioactive material in the nuclear cloud. (Table 3-16 shows AFSWC Air Mission Support at SMOKY).* These two

*The PLUMBBOB series volume describes the Air Force support which was provided both to AEC and DOD-sponsored projects.

Table 3-16. AFSWC AIR MISSION SUPPORT, SHOT SMOKY (11).

Program/ Project	Mission	Type Aircraft	Number of Aircraft	Estimated DOD Personnel
5.3	Effects	FJ-4	1	1
5.4	Effects	A4-D	2	1 per aircraft
5.5	Effects	F89-D	1	2
Program 9	Photography	C-47	1	3+ Lookout Mt. personnel
Program 11	Cloud Sampling	F-84G	2	1 per aircraft
Program 21	Cloud Sampling	B-57	5	2 per aircraft
Program 37	Fallout Studies	C-47	1	3 military + civilians
50.1	Transport for Task Force WARRIOR Security Sweep	Helicopter	44	2 per aircraft + troops ferried
50.8	Atomic Burst Detection	L-20 (H-19) Helicopter	1 4	2 2-4 per aircraft
50.8a	Atomic Burst Detection	B-26	1	2
51.3	Navy Air Crew Indoctrination	F9F-3	3	2 per aircraft
53.1	Cloud Sampling, Training	T-33	4	2 per aircraft
53.7	IBDA	F-89D	1	1
53.8	IBDA	B-47	2	2 per aircraft
53.9	IBDA	RF-84F	2	1 per aircraft
	Sample Courier Return	C-47	3	3 per aircraft + civilian courier
	Security Sweep Liaison	L-20	2	1 per aircraft + civilian security personnel
	Cloud Trackers	B-25 B-29	1 1	3 + monitors (B-25) 5 + monitors (B-29)

efforts were included among the diagnostic projects sponsored by the Wright Air Development Command and the AEC design laboratories. Figure 3-4 shows the planned orbit positions for these aircraft prior to the detonation. AFSWC participation in SMOKY was discussed in sections 3.1 and 3.5.

In the cloud sampling effort, Air Force support included elements of the 4926th Sampler Squadron, which was under the control of the Test Aircraft Unit (Figure 3-7). In addition, elements of fourteen Air National Guard units, which had secondary sampling missions, were placed on active duty for two weeks to receive training and to participate in the sampling activities.

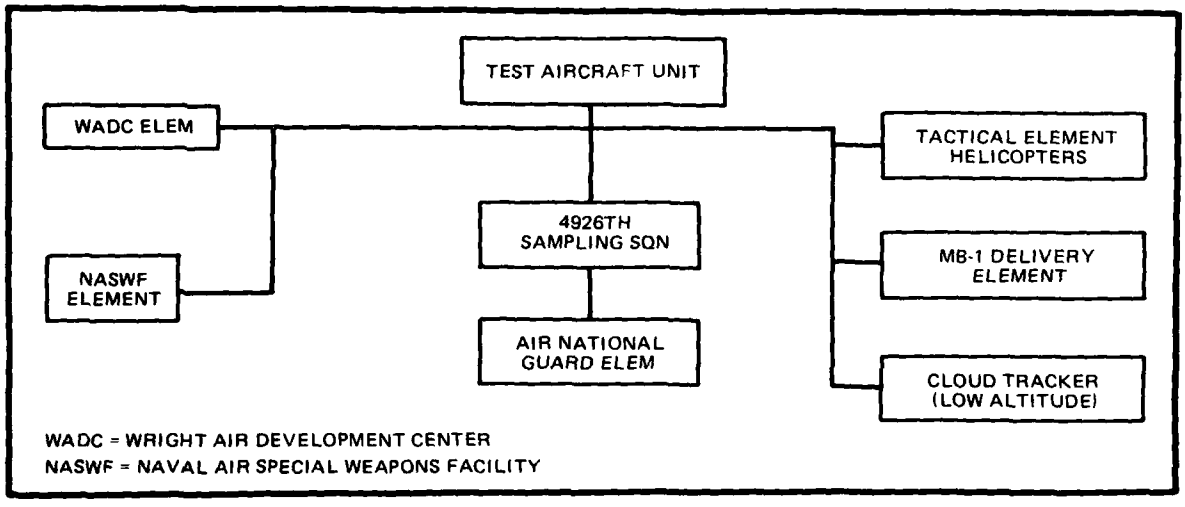

Figure 3-7. TEST AIRCRAFT UNIT ORGANIZATION.

The cloud tracking effort involved a high-level flight (24,000 feet) and a low-level flight (15,000 feet). Flight patterns were not predetermined but depend upon the detonation configuration and the winds. Generally, however, aircraft were to approach the nuclear cloud until the radiacmeter within the aircraft reached a reading between 5 and 10 m/Rh (11). They were to then turn out to avoid contact with the visible cloud. For each data point (between 5 and 10 mR/h), personnel were to record time, altitude, position, and radiacmeter reading. At SMOKY, one B-25 aircraft flew the low-level mission while one B-29 aircraft flew the high-level. The B-25 was provided by the Air Training Command, and was

based at Indian Springs AFB, while the B-29 was provided by the Air Research and Development Command, and was based at Kirtland AFB. Each crew member had a film badge. When the aircraft returned to their home bases, both crew and aircraft were monitored. These multi-engine aircraft were not expected to become contaminated; therefore, no special procedures for decontamination were established.

3.7 JOINT AEC/DOD VISITOR'S BUREAU

The Visitor's Bureau was a joint AEC/DOD activity directly under the AEC Test Manager. Activities of this office did not include the Desert Rock Visitor's Bureau, which was established to serve the needs of that activity. However, the two offices were complementary.* For shot SMOKY, the FCDA and the news media invited 67 official visitors to observe the shot from a separate FCDA observation area near News Nob. In addition, 42 news media observers viewed SMOKY from the media observation area on News Nob at Yucca Pass. Also, some news media personnel accompanied the First Battle Group troops. The AEC provided radiological safety support and security badging for these observers (24).

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*A more detailed description of Visitor's Bureau activities may be found in the PLUMBBOB series volume.

CHAPTER 4
RADIATION EXPOSURE ANALYSIS

4.1 INTRODUCTION

While the preceding chapters discuss such necessary background material as troop and test programs, these primarily set the stage for the most important question: "What was the radiological exposure of the DOD personnel who were present?" In order to answer that question in this chapter, it is necessary to first consider the radiological safety aspects plus the radiological readings and analysis of the radiological environment. This chapter then identifies those units containing DOD personnel which had the opportunity for exposure to ionizing radiation. It should be noted that, although film badge data are generally available for the PLUMBBOB series, it is difficult to assign definite portions of those exposures to SMOKY exclusively. However, preliminary exposure data for Desert Rock personnel are available and an analysis is provided herein. In addition, a dose estimation calculation for Task Force WARRIOR is also included (10).

4.2 THE EXPECTED RADIOLOGICAL ENVIRONMENT

Since SMOKY was a tower shot (700 ft.) with a yield of about 44 kilotons, radioactive debris was expected in the immediate area around GZ, in addition to onsite and offsite. The AEC Test Manager's Fallout Prediction Unit estimated that a total of 1900 megacuries of activity would fall out in an elongated leaf-shaped pattern and would travel generally southwest. The predicted fallout caused some changes in Desert Rock plans for after-shot maneuvers. Due to these changes, all personnel involved were stationed at least eight miles away at H-hour. At this distance the initial radiation from the shot would present no hazard to personnel. The after-shot radiological environment that maneuver troops and recovery teams would be expected to encounter should then consist of the neutron-induced soil activity around GZ and the activity falling out from the radioactive cloud.

4.3 POST-FIRING RADIOLOGICAL DATA

After the detonation of the shot, a variety of radiological readings were taken by REECo (25). The aerial survey team from the General Monitoring Branch departed at 0600 hours. Results obtained from this survey were as follows:

Intensity(mR/h)	Location*	Altitude(ft)	Time
2	BJY	50	0828
40	9-300	50	0831
1	Gate 385	50	0837

Subsequent aerial resurveys indicated the following readings:

Intensity(R/h)	Location*	Altitude(ft)	Time	Resurvey
20.0	Area 7b GZ	50	1314	D-day
0.15	9-356	50	1315	D-day
0.9	Area 9 GZ	50	1317	D-day
200.0	Area 2c GZ	500	1323	D-day
0.2	Area 9 GZ	25	0657	D+1
5.0	Area 7b GZ	25	0652	D+1
0.1	9-356	25	0653	D+1
15.0	Area 2c GZ	500	0700	D+1
50.5	Area 2c GZ	300	0701	D+1

*These locations have not been definitely established. Location BJY was the y-shaped junction of Mercury Highway and the road to Area 7. Locations 9-300 and 9-356 are buildings in Area 9. The GZs listed are shot GZs in Areas 2 and 9. Location 2c is SMOKY GZ.

Results of the ground survey of non-shot areas were as follows:

Intensity(mR/h)	Location	Time	Area
Background	BJY	0551	Yucca Flat
Background	Well 3	0558	Yucca Flat
360	Junction, Area 2 and Area 12 Roads	0615	Yucca Flat
160	BJY	0711	Yucca Flat
150	BJY	0729	Yucca Flat
42	CETG Shelters	0705	2
580	Station 353	0715	Yucca Flat
600	Station 52	0716	Yucca Flat
60	Junction, Area 3 Access Road and Mercury Highway	0805	3
100	Area 3B GZ	0808	3

A check station to control access into the contaminated areas was established at BJY. Two monitors were provided for projects and REECo support. Resurveys of the shot area were made as follows:

Date	Resurvey Days	Midtime Hours
Aug 31	D+1/3	1309
Sept 1	D+1	0628

Results of the surveys were plotted for display at various locations by the Plotting and Briefing Branch. (These are shown in Figures 4-1 through 4-5.) Briefings were conducted and area access permits were certified for each party as follows:

Date	Scheduled Parties	Projects Involved	Personnel Involved
Aug 31	34	12	148
Sept 1	18	13	47
TOTALS	52	25	195

At CP-5, 48 vehicles and two bulldozers were decontaminated by the Decontamination Branch.

The Special Assignment Branch detected no increase in beta-gamma activity in Area 13 and Mercury following the detonation. Surface contamination intensities obtained in the CP-2 area indicated a maximum of 11 mR/h at H+4 hours. Airborne radioactivity (D-day averages) were as follows:

Air samples:

Location	Long-Lived alpha (d/min per m^3)
Warehouse 6	Background
Well 5B	Background
CP-2	0.1
Gate 385	Background
Area 13	0.1
Gate 120	Background
Shot Area (Average)	16.0

Fallout trays:

Location	Long-Lived alpha (d/min per ft^2)
Warehouse 6	Background
Well 5B	Background
CP-2	Background
Gate 385	Background
Area 13	Background
Gate 120	Background
Shot Area (Average)	16.0

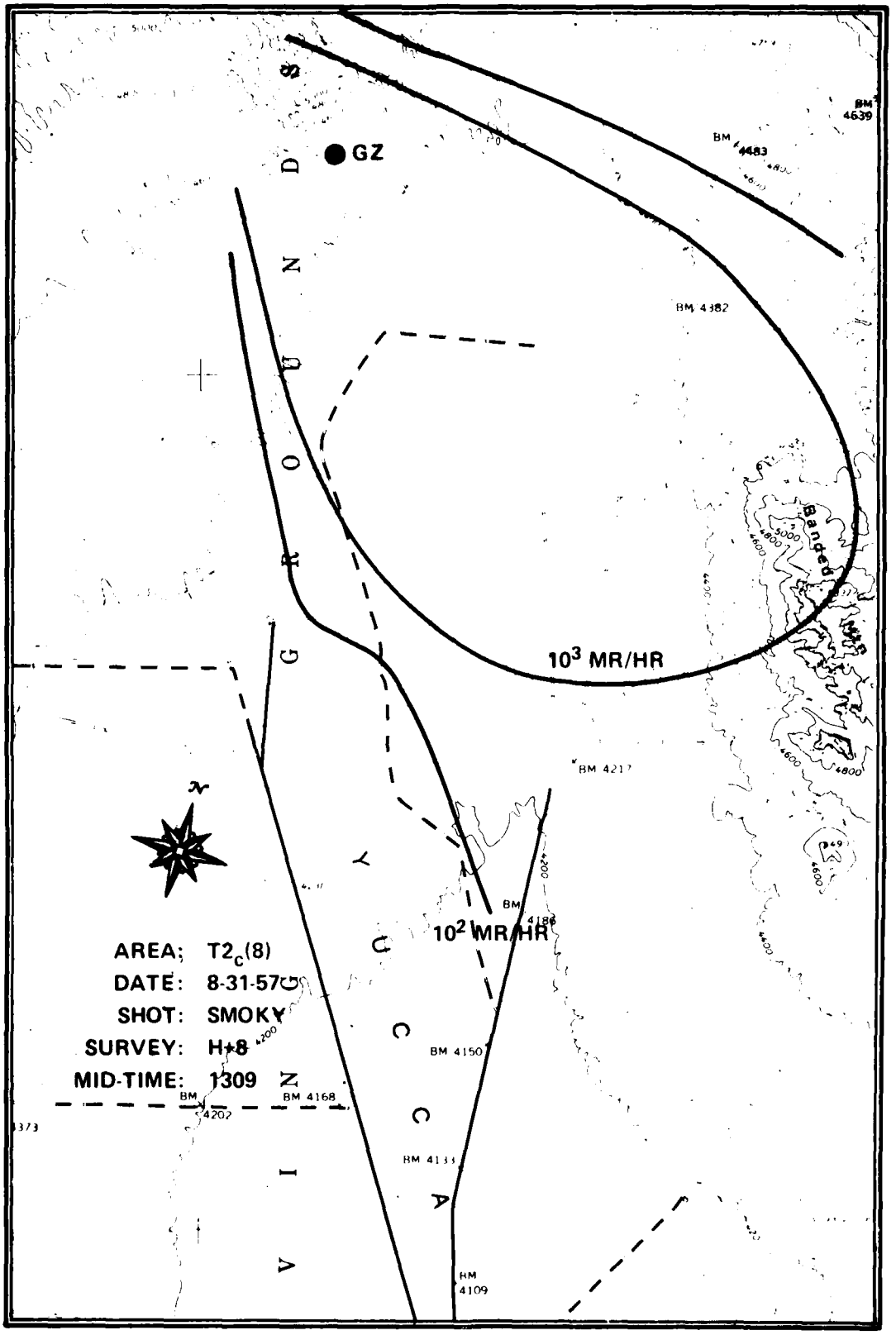


Figure 4-1. SMOKY, H+8.

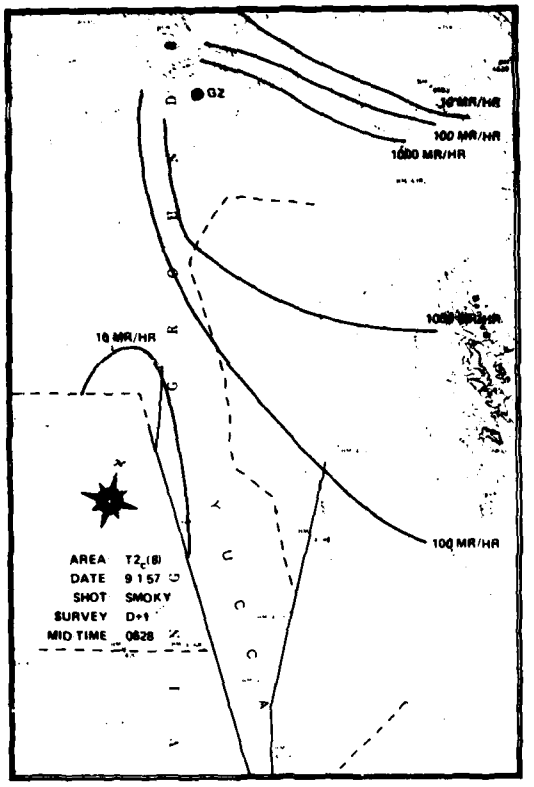
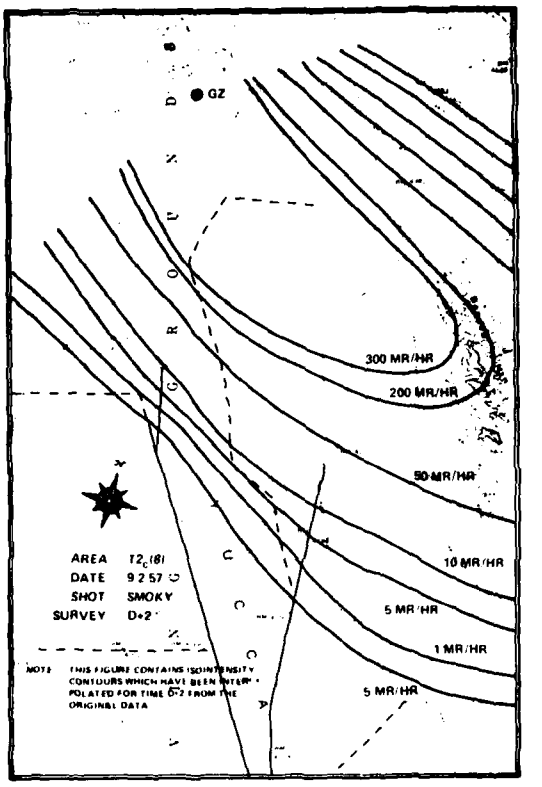


Figure 4-2. SMOKY, D+1



.Figure 4-3. SMOKY, D+2.

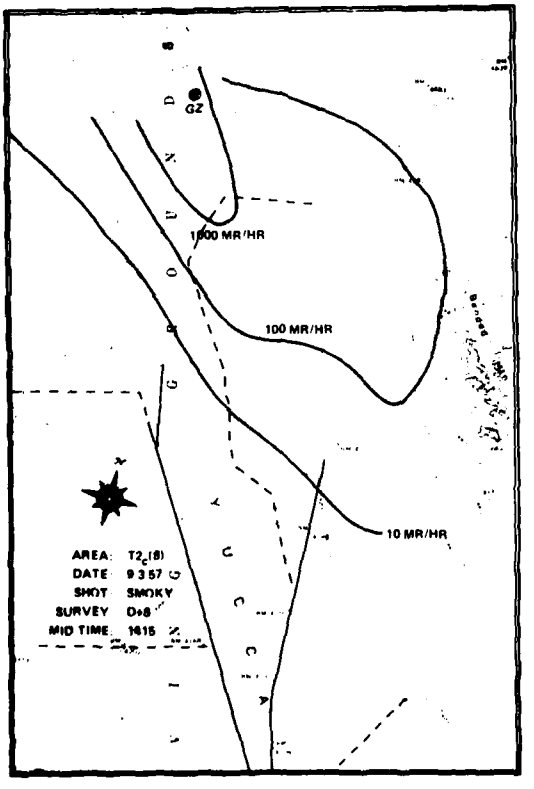


Figure 4-4. SMOKY, D+3.

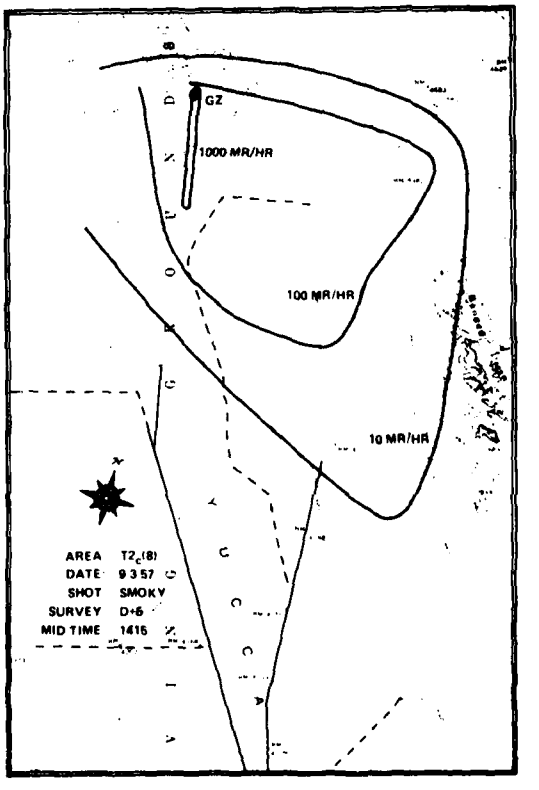


Figure 4-5. SMOKY, D+5.

No increase in radioactivity was noted in well water and drinking water samples. Radiation surveys in "clean working and living areas" in Mercury and the CP area were negative. The following samples were analyzed in the laboratory:

Type	Number
Air Samples	46
Nasal Swabs	20
Fallout Trays	97
Surface Swipes	21
TOTAL	184

The following dosimetry services were provided by the Personnel Dosimetry Branch:

Film badges:

Date	Issued	Processed and Recorded*
Aug 31	137	328
Sept 1	457	442
TOTALS	594	770

Dosimeters:

Date	Issued	Received
Aug 31	102	102
Sept 1	55	55
TOTALS	157	157

The Logistics Branch laundry processed 1,254 anticontamination items. Anticontamination clothing, materials and supplies were issued to 296 people as follows:

Item	Number
Coveralls	233
Shoe Covers (pairs)	313
Respirators	124
Other items	375

*The number of film badges issued does not necessarily correlate with the number processed and recorded, since some personnel may have turned in badges and departed instead of drawing new badges.

4.4 SMOKY RADIOLOGICAL ENVIRONMENT

It should be recognized that the location and times of concern regarding personnel ranged from several miles from GZ at detonation to within 2,000 yards of GZ about 100 hours after detonation. Therefore, the main sources for the radiological environment at SMOKY were neutron-induced soil activity and fallout. However, data are presented here on all three sources (initial, neutron-induced and fallout) to assist the reader in reconstructing the total radiological environment.

4.4.1 Initial Radiation

Neutrons. Information about neutron flux and dose measurements for a number of shots, including SMOKY, is reported in references 14, 21 and 29. Some of the figures and tables in this section summarize that information for SMOKY in terms of methodology and effects. On the methodology side, Table 4-1 for example, lists the locations of the various detector stations where the measurements were taken. These locations are shown in Figure 4-6. The terrain profiles along two azimuthal lines from GZ, the 58° line, and the 353° line, are shown in Figures 4-7 and 4-8, respectively. (The view along the 167° line was not plotted but can be computed from Table 4-1.) Table 4-2 lists the different types of neutron threshold detectors used in SMOKY.

In terms of effects, the flux data collected for SMOKY are presented in Table 4-3 while plots of the data are presented in Figures 4-9, 4-10 and 4-11. The neutron dose data are given in terms of two different atmospheric conditions: actual, that is, the atmosphere as measured at shot time, and standard, an atmosphere with a pressure of 1.013 bars and a temperature of 15° C. Actual meteorological conditions for the SMOKY shot are presented in Table 4-4. Reducing dose data to the standard atmosphere provides a common framework for comparing neutron doses from various sources and different environments. In this study, the germane values of fluxes and doses are those corresponding to actual weather conditions at and near shot time.

The neutron dose measurements are tabulated in Table 4-5 for both the actual and standard atmospheres. The plots of these data are presented in Figures 4-12, 4-13 and 4-14. The variation of dose along the different directions can be

Table 4-1. DETECTOR LOCATIONS FOR SHOT SMOKY.

Station Number	Azimuth (deg)	Radial Distance from Ground Zero (yd)	Elevation with Respect to Ground Zero (ft)	Slant Range (yd)	Description	Instrumenting Agency
400 S	167	400	-20	466	Au, Pu, Np, U, NBS-F,[a] GD[b]	Project 2.3
600 S	167	600	-60	649	Au, Pu, Np, U, NBS-F, GD, CD[c]	Project 2.3
800 S	167	800	-80	841	Au, Pu, Np, U, NBS-F, GD, CD	Project 2.3
1,000 S	167	1,000	-95	1,034	Au, Pu, Np, U, NBS-F, GD, CD	Project 2.3
1,200 S	167	1,200	-105	1,229	Au, Pu, Np, U, NBS-F, GD, CD	Project 2.3
1,400 S	167	1,400	-120	1,426	Au, Pu, Np, U, NBS-F, GD, CD	Project 2.3
1,500 S	167	1,500	-120	1,525	Au, Pu, Np, U, NBS-F, GD, CD	Project 39.5
1,600 S	167	1,600	-125	1,623	Au, Pu, Np, U, NBS-F, GD, CD	Project 39.5
1,700 S	167	1,700	-125	1,722	Au, Pu, Np, U, NBS-F, GD, CD	Project 39.5
1,800 S	167	1,800	-130	1,821	Au, Pu, Np, U, NBS-F, GD, CD	Project 39.5
1,900 S	167	1,900	-130	1,920	Au, Pu, Np, U, NBS-F, GD, CD	Project 39.5
2,000 S	167	2,000	-135	2,019	Au, Pu, Np, U, NBS-F, GD, CD	Project 39.5
450 N	353	450	+60	498	Au, Pu, Np, U, NBS-F, GD, CD	Project 2.3
600 N	353	600	+130	629	Au, Pu, Np, U, NBS-F, GD, CD	Project 2.3
700 N	353	700	+210	719	Au, Pu, Np, U, NBS-F, GD, CD	Project 2.3
825 N	353	825	+360	833	Au, Pu, Np, U, NBS-F, GD, CD	Project 2.3
900 N	353	900	+480	903	Au, Pu, Np, U, NBS-F, GD, CD	Project 2.3
930 N	353	930	+520	933	Au, Pu, Np, U, NBS-F, GD, CD	Project 2.3
1,000 N	353	1,000	+470	1,003	Au, Pu, Np, U, NBS-F, GD, CD	Project 39.5
1,100 N	353	1,100	+350	1,106	Au, Pu, Np, U, NBS-F, GD, CD	Project 39.5
400 E	58	400	+30	458	Au, Pu, Np, U, SB-100[d]	Project 2.3
500 E	58	500	+45	545	Au, Pu, Np, U, SB-100[d]	Project 2.3
565 E	58	565	+38	607	Au, Pu, Np, U, SB-100	Project 2.3
610 E	58	610	+21	651	Au, Pu, Np, U, SB-100, CD	Project 2.3
660 E	58	660	+44	691	Au, Pu, Np, U, SB-100, CD	Project 2.3
725 E	58	725	+56	756	Au, Pu, Np, U, NBS-F, GD, CD, SB-100	Project 2.3
780 E	58	780	+46	810	Au, Pu, Np, U, NBS-F, GD, CD, SB-100	Project 2.3
810 E	58	810	+36	841	Au, Pu, Np, U, NBS-F, GD, CD, SB-100	Project 2.3
860 E	58	860	+48	887	Au, Pu, Np, U, NBS-F, GD, CD, SB-100	Project 39.5
955 E	58	955	+41	980	Au, Pu, Np, U, NBS-F, GD, CD, SB-100	Project 39.5
965 E	58	965	+30	990	Au, Pu, Np, U, NBS-F, GD, CD	Project 39.5
975 E	58	975	+16	1,001	Au, Pu, Np, U, NBS-F, GD, CD	Project 39.5
1,020 E	58	1,020	+12	1,045	Au, Pu, Np, U, NBS-F, GD, CD, SB-100	Project 39.5
1,080 E	58	1,080	+21	1,098	Au, Pu, Np, U, NBS-F, GD, CD, SB-100	Project 39.5
1,140 E	58	1,140	+2	1,164	Au, Pu, Np, U, NBS-F, GD, CD	Project 39.5
1,250 E	58	1,250	-20	1,268	Au, Pu, Np, U, NBS-F, GD, CD	Project 39.5
1,400 E	58	1,400	-36	1,421	Au, Pu, Np, U, NBS-F, GD, CD	Project 39.5
1,600 E	58	1,600	-30	1,618	NBS-F, GD ———	Project 39.5
1,800 E	58	1,800	-20	1,816	NBS-F, GD ———	Project 39.5

[a]National Bureau of Standards film packet.

[b]Germanium dosimeters.

[c]Chemical dosimeters.

[d]Punch-through voltage transistor dosimeter.

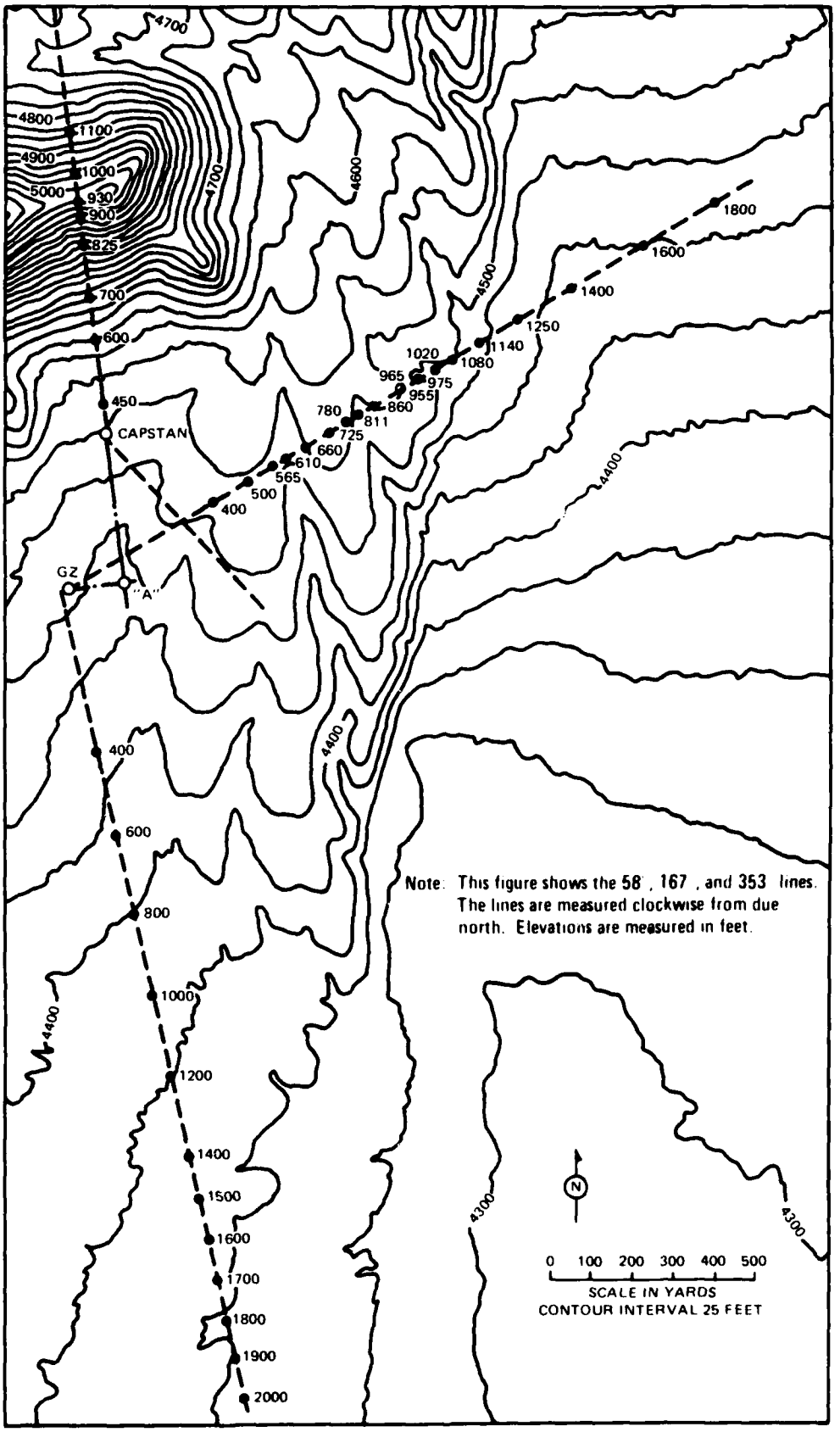


Figure 4-6. TOPOGRAPHICAL VIEW OF STATION LOCATIONS FOR SHOT SMOKY.

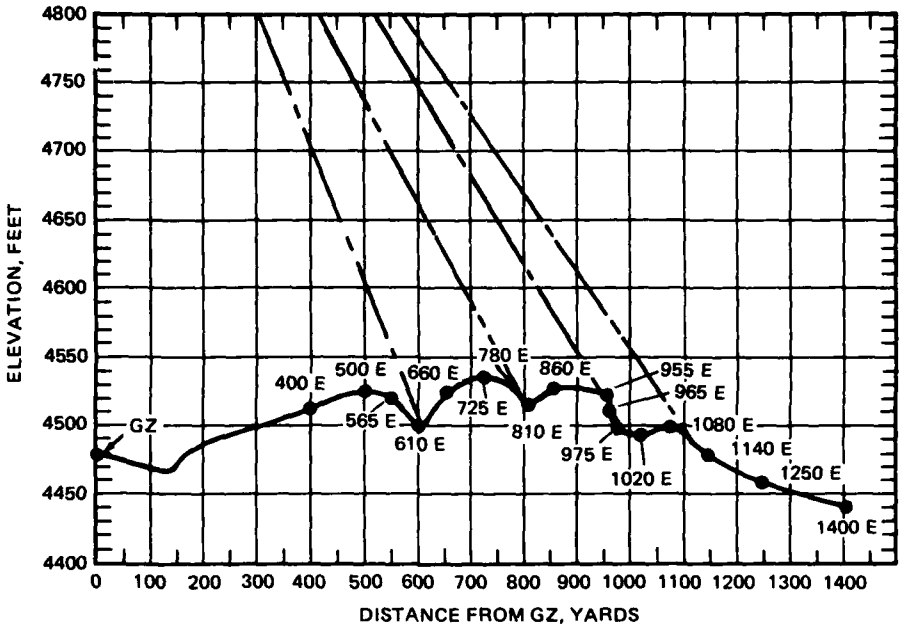


Figure 4-7. PROFILE OF STATION LOCATIONS ON THE 58-DEGREE LINE FOR SHOT SMOKY.

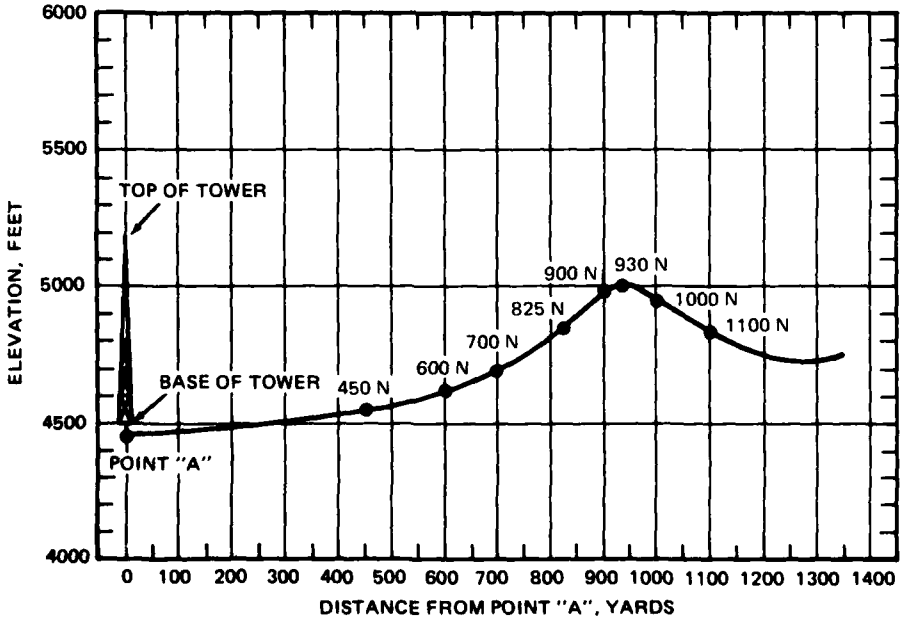


Figure 4-8. PROFILE OF STATION LOCATIONS ON THE 353-DEGREE LINE FOR SHOT SMOKY.

Table 4-2. NEUTRON THRESHOLD DETECTORS.

Detector	Threshold Energy	Reaction
Gold	Thermal to 0.3 ev	Au^{197} (n,γ) Au^{198}
Pu^{239}	10 kev (with B^{10} shield)	Fission
Np^{237}	0.63 Mev	Fission
U^{238}	1.5 Mev	Fission

Table 4-3. NEUTRON THRESHOLD DETECTOR MEASUREMENTS FOR SHOT SMOKY.

Station Number	Distance from Ground Zero (yds)	Slant Range (yds)	Measured Flux			
			Au (n/cm^2)	Pu (n/cm^2)	Np (n/cm^2)	U (n/cm^2)
400 S	400	466	2.18×10^{13}	7.46×10^{13}	4.99×10^{13}	———
600 S	600	649	———	2.16×10^{13}	1.22×10^{13}	1.95×10^{12}
800 S	800	841	1.59×10^{12}	5.90×10^{12}	———	5.52×10^{11}
1,000 S	1,000	1,034	4.85×10^{11}	2.31×10^{12}	———	1.11×10^{11}
1,200 S	1,200	1,229	1.69×10^{11}	7.14×10^{11}	———	———
1,400 S	1,400	1,426	———	6.07×10^{11}	———	———
450 N	450	498	4.75×10^{13}	8.23×10^{13}	6.74×10^{13}	9.26×10^{12}
600 N	600	629	1.54×10^{13}	4.08×10^{13}	3.35×10^{13}	4.85×10^{12}
700 N	700	719	6.80×10^{12}	2.23×10^{13}	1.66×10^{13}	2.95×10^{12}
825 N	825	833	1.67×10^{12}	1.31×10^{13}	9.89×10^{12}	1.47×10^{12}
900 N	900	903	2.15×10^{12}	9.37×10^{12}	———	8.53×10^{11}
930 N	930	933	1.64×10^{12}	———	———	6.51×10^{11}
400 E	400	458	6.73×10^{13}	9.90×10^{13}	8.87×10^{13}	1.72×10^{13}
500 E	500	545	2.38×10^{13}	4.79×10^{13}	4.16×10^{13}	6.16×10^{12}
565 E	565	607	1.42×10^{13}	4.06×10^{13}	3.60×10^{13}	4.91×10^{12}
605 E	605	651	8.31×10^{12}	2.96×10^{13}	2.51×10^{13}	3.62×10^{12}
660 E	660	691	6.25×10^{12}	2.03×10^{13}	1.48×10^{13}	2.79×10^{12}
725 E	725	756	3.69×10^{12}	1.31×10^{13}	8.88×10^{12}	1.72×10^{12}
780 E	780	810	2.75×10^{12}	9.64×10^{12}	8.26×10^{12}	1.19×10^{12}
810 E	810	841	———	7.41×10^{12}	6.92×10^{12}	9.84×10^{11}

Pu = Plutonium
Np = Neptunium
U = Uranium
Au = Gold

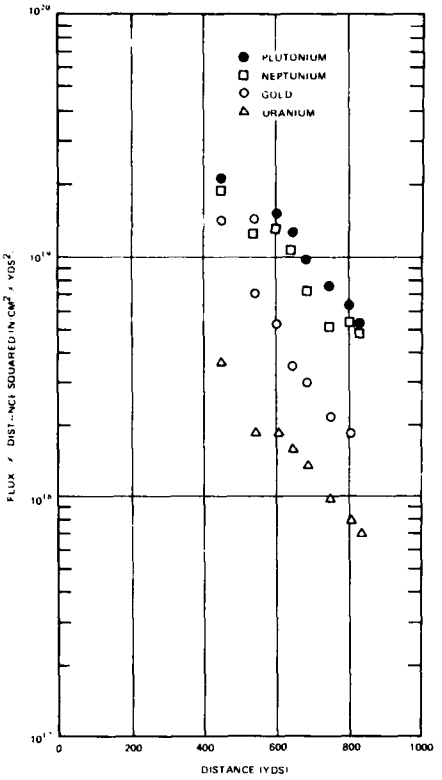


Figure 4-9. NEUTRON THRESHOLD DETECTOR RESULTS FOR THE 68-DEGREE LINE FOR SHOT SMOKY.

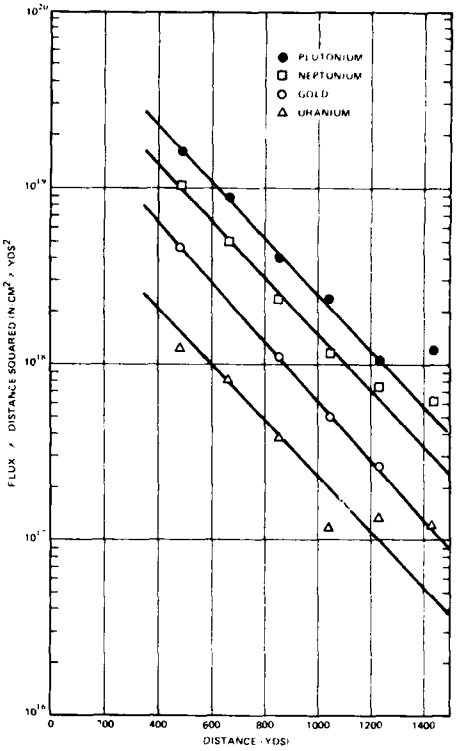


Figure 4-10. NEUTRON THRESHOLD DETECTOR RESULTS FOR THE 167-DEGREE LINE FOR SHOT SMOKY.

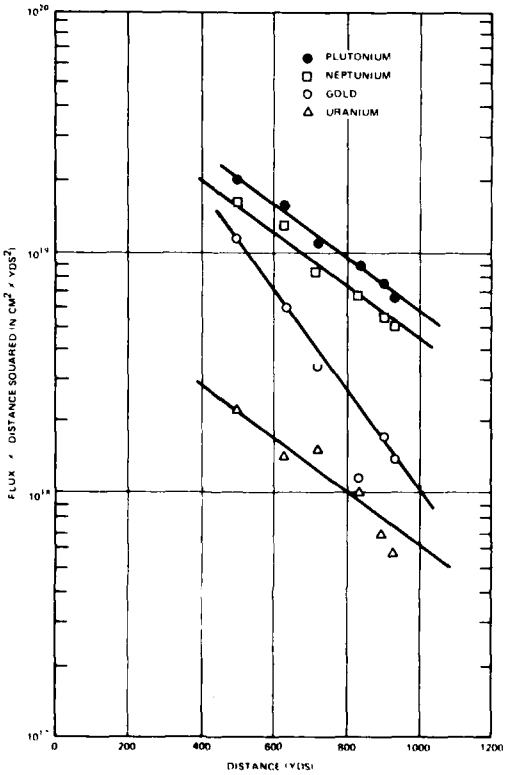


Figure 4-11. NEUTRON THRESHOLD DETECTOR RESULTS FOR THE 383 DEGREE LINE FOR SHOT SMOKY.

Table 4-4. ACTUAL METEOROLOGICAL CONDITIONS FOR SHOT SMOKY.

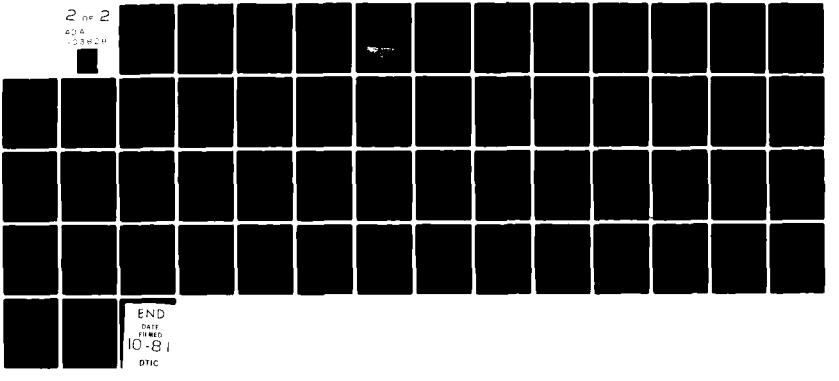
Height Above Sea Level (ft)	Pressure (mb)	Temperature (°C)	Relative Humidity (%)
4479.2	856	14.0	31
4938.0	850	15.5	32
5000.0	848	15.4	32
5179.0	844	15.2	32
6000.0	817	13.8	32

Table 4-5. NEUTRON DOSE UNDER ACTUAL AND STANDARD CONDITIONS FOR SHOT SMOKY.

Station Number	Distance from Ground Zero (yds)	Azimuth (deg)	$\bar{\rho} = 0.83$		$\bar{\rho} = 1.0$	
			Slant Range (yds)	Dose (rep)	Slant Range (yds)	Dose (rep)
400 S	400	167	466	1.55×10^5	387	2.24×10^5
600 S	600	—	649	4.17×10^4	539	6.04×10^4
800 S	800	—	841	1.15×10^4	698	1.67×10^4
1,000 S	1,000	—	1,034	4.13×10^3	858	5.99×10^3
1,200 S	1,200	—	1,229	1.56×10^3	1,020	2.26×10^3
1,400 S	1,400	—	1,426	1.12×10^3	1,184	1.62×10^3
450 N	450	353	498	1.92×10^5	413	2.78×10^5
600 N	600	—	629	9.57×10^4	522	1.39×10^5
700 N	700	—	719	5.00×10^4	597	7.25×10^4
825 N	825	—	833	2.93×10^4	691	4.25×10^4
900 N	900	—	903	2.04×10^4	749	2.96×10^4
930 N	930	—	933	1.74×10^4	774	2.52×10^4
400 E	400	58	458	2.47×10^5	380	3.58×10^5
500 E	500	—	545	1.16×10^5	452	1.68×10^5
565 E	565	—	607	9.92×10^4	504	1.44×10^5
605 E	605	—	657	7.09×10^4	545	1.03×10^5
660 E	660	—	691	4.52×10^4	573	6.55×10^4
725 E	725	—	756	2.82×10^4	627	4.09×10^4
780 E	780	—	810	2.32×10^4	672	3.36×10^4
810 E	810	—	841	1.88×10^4	698	2.73×10^4

* Under actual conditions, the mean density was approximately 0.83 of that of the standard atmosphere. Partial pressure of water vapor is neglected.

AD-A103 828 JAYCOR ALEXANDRIA VA F/G 18/3
SHOT SMOKY, A TEST OF THE PLUMBBOB SERIES, 31 AUGUST 1957.(U)
MAY 81 P S HARRIS, C LOWERY, A G NELSON DNA001-78-C-0311
UNCLASSIFIED JAYCOR-2087-79-01 DNA-6004F NL



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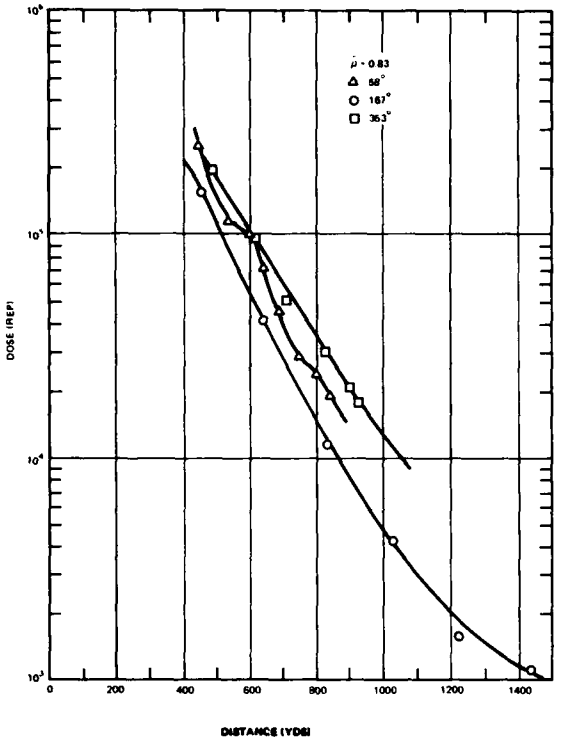

Figure 4-12. NEUTRON THRESHOLD DETECTOR DOSE VS. DISTANCE FOR SHOT SMOKY UNDER ACTUAL ATMOSPHERIC CONDITIONS.

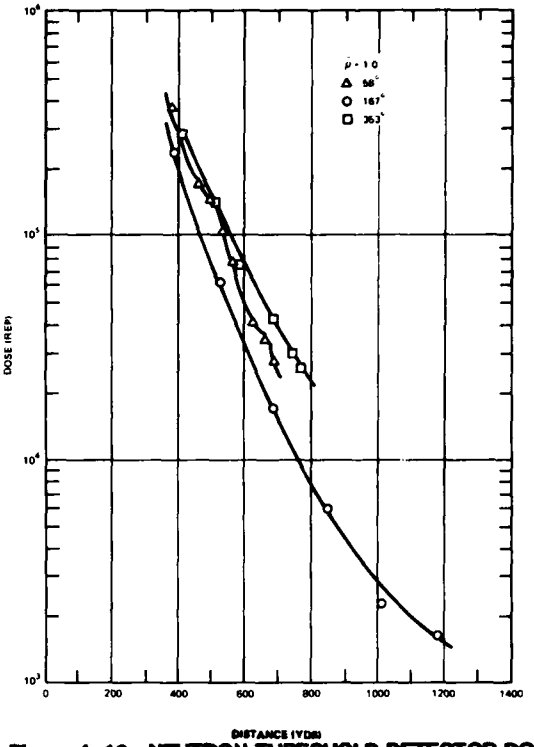

Figure 4-13. NEUTRON THRESHOLD DETECTOR DOSE VS. DISTANCE FOR SHOT SMOKY UNDER ACTUAL ATMOSPHERIC CONDITIONS.

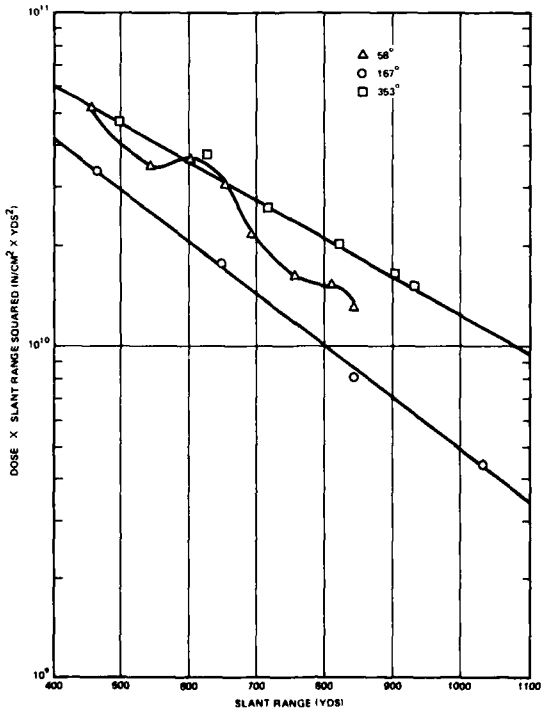

Figure 4-14. NEUTRON THRESHOLD DETECTOR DOSE-DISTANCE SQUARED VS. DISTANCE FOR SHOT SMOKY.

attributed to at least three factors: different terrains, anisotropic emission of neutrons from the detonating device, and the substantial shield in the cab floor.

Gamma Rays. Data related to initial gamma ray production in the SMOKY test are given in references 12, 30 and 31. References 30 and 31 are of particular interest as sources of initial gamma ray data for all weapon tests through 1962 and for Operation PLUMBBOB (including shot SMOKY). Reference 12 also contains gamma dose measurements taken in a variety of shelters and experimental structures. Reference 30 discusses the response of various chemical systems to ionizing radiation. For example, chloroform responds to gamma radiation by producing water soluble acids which are then used as a measure of dose.

Calibrated films in special holders were the primary means of detecting gamma ray dose (12; 30). Although the film data were corrected for the effect of the initial neutrons on the film, they did contain the contribution from neutron-induced soil activity. At 650 yards from GZ, the soil contributed approximately 7 percent to the reported dose (1) and at 800 yards, approximately 5.5 percent (35). The accuracy of the gamma ray dose was $\pm$ 25 to 35 percent (30).

Table 4-6 lists corrected and uncorrected gamma ray dose data for shot SMOKY. These data are plotted in Figure 4-15 as a function of slant range.

4.4.2 Neutron-Induced Activity

In shot SMOKY, as in the other shots at Operation PLUMBBOB, the primary isotopes responsible for soil-induced activity were sodium-24, manganese-56, and aluminum-26. Neutron-induced activity appeared after the prompt neutron irradiation and decayed with time. For the type of soil at the Nevada Test Site, approximately a tenfold decrease occurred in the first 10 hours. As the shorter-lived isotopes, such as manganese-56 and aluminum-26, disappeared from the soil, the rate of decay declined. Consequently, in the next 40 hours, the soil activity again declined by a factor of ten.

Table 4-6. INITIAL GAMMA DOSE DATA FOR SHOT SMOKY.

Slant Range	Azimuth	Type of Dosimeter	Uncorrected Gamma Dose (r)	Neutron Flux				All Correction (R)	Fast Correction (R)	Shield Correction (R)	Total Correction (R)	Corrected Gamma Dose (R)	Attenuation Factor	Final Corrected Gamma Dose (R)	Soil Contribution
				Au (n/cm^2)	Pu (n/cm^2)	Np (n/cm^2)	U (n/cm^2)								
651	a	b	47,000	8.31×10^{12}	2.96×10^{12}	2.51×10^{12}	3.6×10^{12}	d	d	239.0	239.0	46,800	1.05	49,100	3,600
691	a	b	37,000	6.25×10^{12}	2.03×10^{12}	1.48×10^{12}	2.7×10^{12}	d	d	180.0	180.0	36,800	1.05	38,600	2,490
750	a	b	25,000	3.69×10^{12}	1.31×10^{12}	8.89×10^{12}	1.7×10^{12}	d	d	106.0	106.0	24,900	1.05	26,100	1,520
810	a	b	19,000	2.75×10^{12}	9.64×10^{12}	8.26×10^{12}	1.1×10^{12}	d	d	079.2	079.2	18,900	1.05	19,200	1,110
841	a	b	13,500		7.41×10^{12}	6.92×10^{12}	9.8×10^{12}	d	d	—	—	—	1.05	—	—
887	a	b	15,500	c	c	c	c	d	d	—	—	—	1.05	—	—
980	a	b	9,800	c	c	c	c	d	d	—	—	—	1.05	—	—
990	a	b	4,300	c	c	c	c	d	d	—	—	—	1.05	—	—
1,001	a	b	5,400	c	c	c	c	d	d	—	—	—	1.05	—	—
1,026	a	b	6,000	c	c	c	c	d	d	—	—	—	1.05	—	—
1,093	a	b	5,700	c	c	c	c	d	d	—	—	—	1.05	—	—
1,164	a	b	4,300	c	c	c	c	d	d	—	—	—	1.05	—	—
1,268	a	b	2,575	c	c	c	c	d	d	—	—	—	1.05	—	—
1,421	a	b	1,175	c	c	c	c	d	d	—	—	—	1.05	—	—
1,618	a	b	580	c	c	c	c	d	d	—	—	—	1.05	—	—
1,816	a	b	230	c	c	c	c	d	d	—	—	—	1.05	—	—

[a] 90°

[b] Chemical.

[c] Since terrain effects were very pronounced, the neutron data cannot be extrapolated to the greater distances.

[d] Negligible.

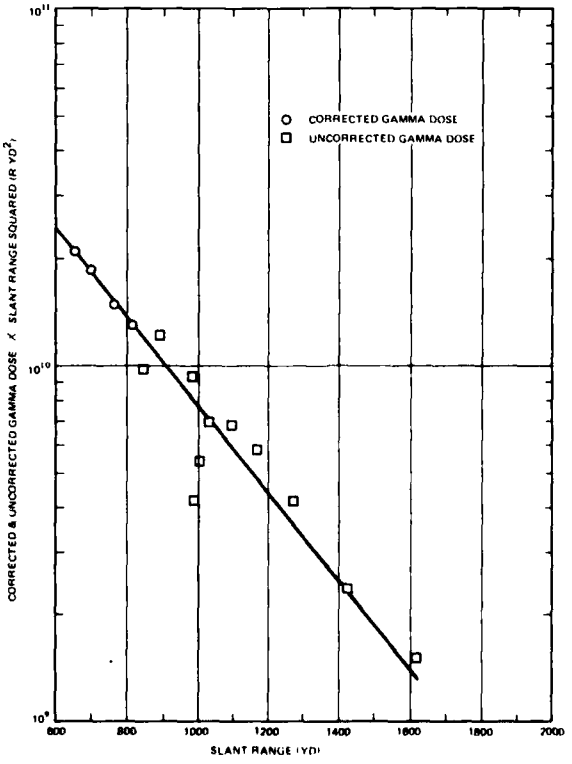

Figure 4-18. CORRECTED AND UNCORRECTED GAMMA-DOSE-TIMES-SLANT-RANGE-SQUARED VS. SLANT RANGE FOR SHOT SMOKY.

Measurements of neutron soil activity were made throughout Operation PLUMBBOB, including shot SMOKY. For shots where fallout in the immediate vicinity of ground zero was negligible, the neutron-induced soil activity could be measured directly. For shots like SMOKY, where the local fallout was heavy, calculations of neutron-induced soil activity and dose could be improved by basing them on the overall measurements made during PLUMBBOB. At SMOKY, the fraction of the dose received from soil activity was small in comparison to that of the fallout. (At H+1 hour, the soil contributed only a few percent to the total dose.) In any case, the dose received from the neutron activation as well as from the fallout is included in the isodose rate contours that were measured by Rad-safe monitors and used to control personnel movement in the area.

4.4.3 Fallout

The fallout activity at SMOKY consisted primarily of beta and gamma radiation from the fission products and from the neutron-activated material (17, 19, 20, 25). An alpha radiation component was also present as a result of unfissioned bomb material.

Using the AN/PDR 39 and AN/PDR 43 ionization chambers, REECo monitors surveyed the ground at the SMOKY site, measuring along eight radial roads extending from SMOKY ground zero and other specific locations. The surveys were first made at H+8 hours and again at D+1 day, D+3 days, and D+5 days. The survey measurements were plotted as isodose rate maps, which were then used to determine the size and location for SMOKY Radex areas. These isodose rate maps (Figures 4-1 through 4-5) indicate the total dose rates from all sources of radiation at the times of measurement indicated. Rad-safe personnel used the maps to determine how long personnel could stay in contaminated areas to perform post-shot operations.

Studies made during PLUMBBOB Project 37 (17) provide more detailed information on the local fallout. Although this project dealt primarily with offsite fallout, the data nevertheless help explain the nature of the local fallout (on site, near surface ground zero). Figure 4-16 shows dose rate contours at H+12 hours, as well as arrival times and predominant particle size along certain arcs. Figure 4-17 shows additional information on particle sizes. These data show that the local fallout consisted predominantly of particle sizes larger than ten microns.

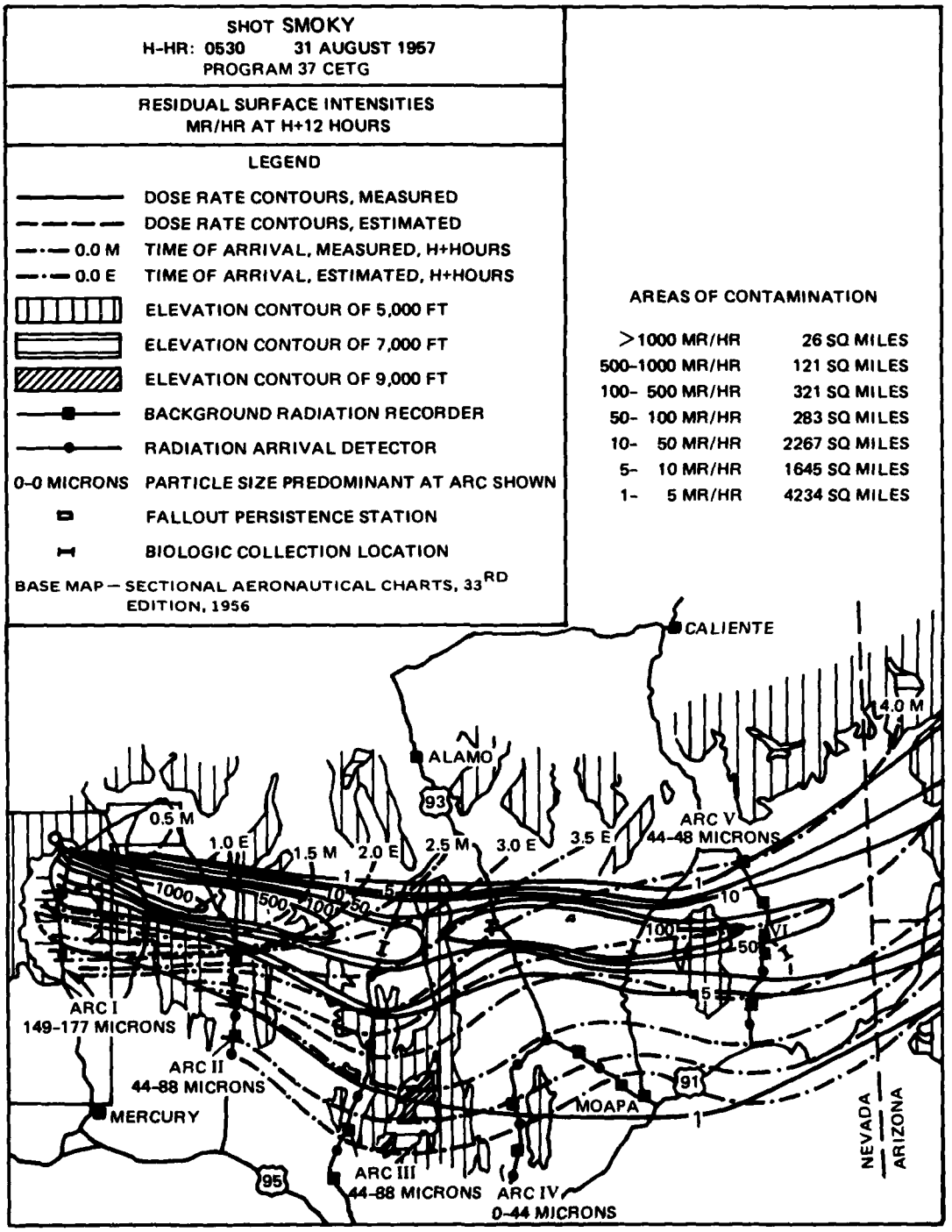

Figure 4-16. FALLOUT PARTICLE DISTRIBUTION FOR SHOT SMOKY.

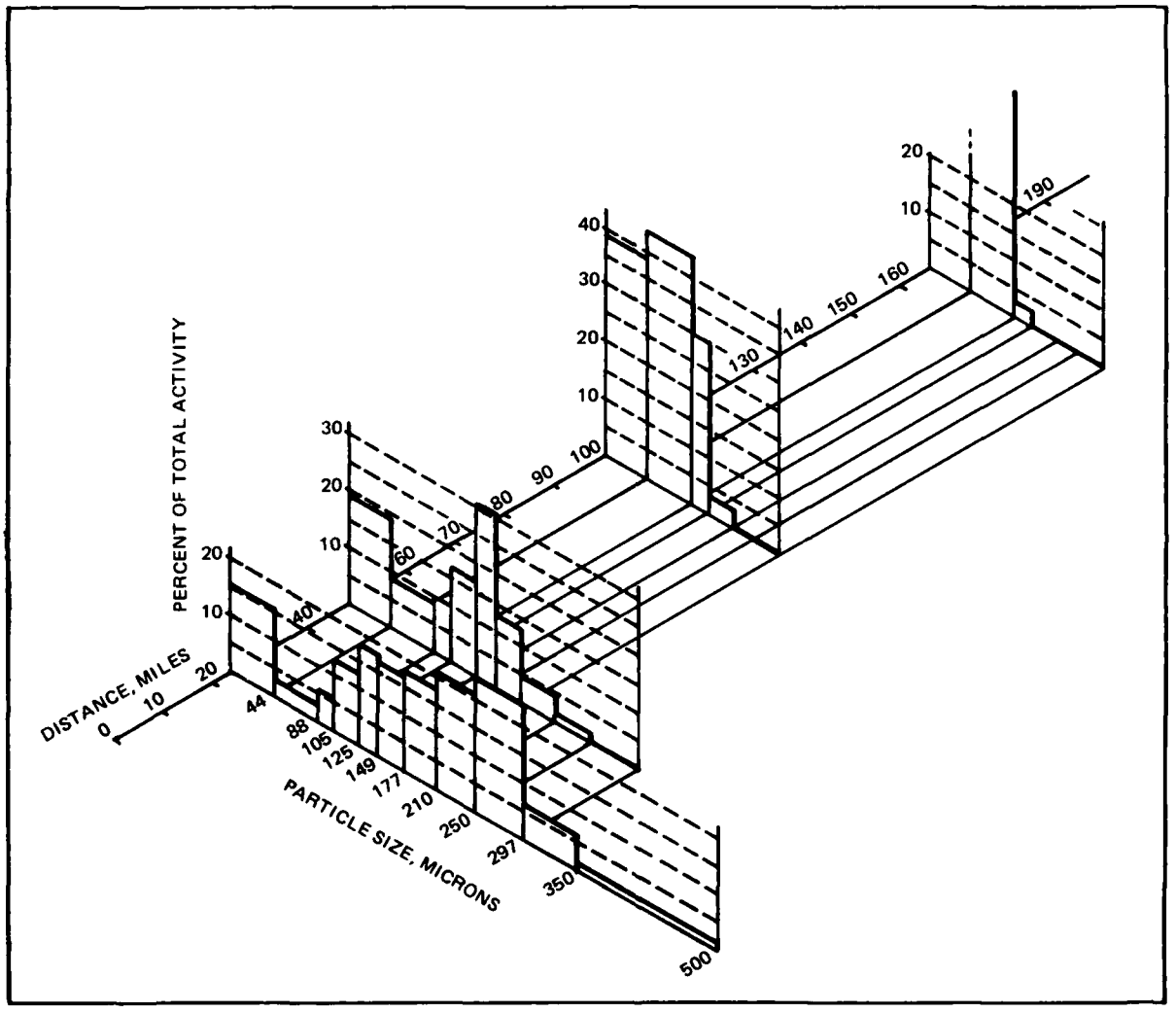

Figure 4-17. PARTICLE SIZE DISTRIBUTION FOR SHOT SMOKY.

Additional data on SMOKY fallout appear in Table 4-7 and Figure 4-19 (19). The table shows wind data, and the figure shows isodose rate contours extrapolated to H+1 hour. Expression of dose rates extrapolated to H+1 hours does not represent the actual dose rate on the ground at that time, since fallout for shot SMOKY was not yet complete. However, this expression did provide the basis for computing dose rates at some time after fallout was completed. At shot SMOKY, the initial survey was at H+8 hours so the normalized (H+1) dose rate contours would not be valid prior to that time.

The wind data are further elaborated in the wind vector diagrams of Figure 4-20. A particle originating at some altitude over ground zero and falling at a given rate in the wind distribution shown in Table 4-7 would reach the ground at a determinable location. Such locations for a fall rate of 5,000 ft/hr are shown in the hodographs of Figure 4-20. Each leg of the hodograph represents the direction and horizontal distance traveled by an average particle when falling through successive wind layers from cloud top to the earth. Thus, the point at 52.5 miles represents an average particle which started at cloud top, and the intermediate lines are loci for average particles falling from other altitudes within the cloud. Figure 4-21 displays the predicted SMOKY offsite contours.

In summary, the measured total fallout was slightly more than the predicted value, and the bearing of the pattern, which had been based on the wind pattern at H-2 hours, was more to the southeast than the prediction. The total SMOKY fallout activity exceeded that of any other shot at PLUMBBOB; a typical value for a PLUMBBOB shot was about 1/10 to 1/20 that of SMOKY.

4.5 EXERCISE DESERT ROCK RADIOLOGICAL SAFETY

The Exercise Desert Rock Rad-safe section operated under procedures published as a part of the exercise operations order (23). This delineated the radiological safety procedures used to implement the Exercise Desert Rock PLUMBBOB procedures for SMOKY (See Figure 4-18).

Although the specified procedures were, in many cases, the same as those used by the AEC, some applications were tailored to the needs of the Exercise Desert Rock Rad-safe program. On D-1 (day before the shot) entry into all

DESERT ROCK RADIOLOGICAL SAFETY PROCEDURES FOR SMOKY

The following procedures have been paraphrased from the Operations Order for SMOKY (23). They are provided as a basis for evaluation of the radiological safety activities. Since these procedures were written prior to the decision not to occupy trenches, the instructions for such activities are not pertinent and have been deleted.

One motorized, radio-equipped radiological monitoring team (Rad-safe Section) was to monitor the ridge along points marked R & S (reconnaissance and security), as shown on the map in Figure 2-3 (map coordinates 753042). One monitor from the Rad-safe Section was to accompany each Pathfinder helicopter. Pathfinder teams were to monitor their assigned areas of operation and report the initial dose rate reading as well as changes in dose rate at 10 mR/h intervals. Evacuation from operation areas, if required, was to be at the direction of the Rad-safe Officer.

All patrols operating during the Infantry Troop Tests were to include a qualified radiological monitor as a member of the patrol. Reports were to be as indicated for Pathfinders (above). Two monitoring teams from the Rad-safe Section were to monitor the equipment display area and erect yellow cones to mark the 20 mR/h line and red cones to mark the 5 R/h line. A military police (MP) checkpoint was to be established where the 20 mR/h line crossed the access road. The teams were then to survey the sector approaching ground zero. It was assumed this would be roughly semicircular south of GZ since there were no access roads to the north. The 5 R/h line was to be marked every 30 yards with a red cone. The cones then were to be connected with white engineer tape. The teams then would each survey half of the sector for hot spots (areas of high intensity). If found, such spots were to be marked with engineer tape and red cones.

All personnel were to fit and test their protective masks before going to the forward area. Masks were to be donned if dust was excessive or if personnel were ordered to do so.* Observers were to close their eyes, cover their faces with their arms, and face away 180 degrees from the detonation point from the time ordered to do so until 5 seconds after the detonation. Personnel visiting the display area were to refrain from touching demonstration equipment or picking up and keeping any objects for souvenirs. Safety regulations published by Camp Desert Rock Headquarters were to be complied with by all personnel assigned or attached to Camp Desert Rock for participation in shot SMOKY. Drivers trained as monitors were to draw the necessary radiac instruments and act as the personnel and vehicle monitors for their vehicles. Personnel vehicles were not to enter areas with intensities of 20 mR/h or greater. All personnel were to evacuate the equipment display area and return to their transportation if at any time they saw red smoke.

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*This instruction was directed at personnel in the trenches. Though the trenches were not occupied, it can be assumed that a similar precaution might be applicable to others entering the display/trench area after the burst.

Figure 4-18. DESERT ROCK RADIOLOGICAL SAFETY PROCEDURES FOR SMOKY.

Table 4-7. NEVADA WIND DATA FOR SHOT SMOKY.

Altitude (ft MSL)	H-Hour		H+3 Hours		Altitude (ft MSL)	H-Hour		H+3 Hours	
	Dir (degrees)	Speed (mph)	Dir (degrees)	Speed (mph)		Dir (degrees)	Speed (mph)	Dir (degrees)	Speed (mph)
Surface	Calm	Calm	Calm	Calm	29,000	280	36	—	—
5,000	Calm	Calm	330	05	30,000	280	37	300	33
5,179	Calm (BH)	Calm	—	—	31,000	280	33	—	—
6,000	340	06	350	05	32,000	280	36	—	—
7,000	010	07	060	07	33,000	270	38	—	—
8,000	010	07	080	09	34,000	270	37	—	—
9,000	010	10	040	06	35,000	270	37	300	35
10,000	360	12	360	06	36,000	270	40	—	—
11,000	360	09	—	—	37,000	270	44	—	—
12,000	360	07	360	05	38,000	270	43	—	—
13,000	360	07	—	—	39,000	270	39	—	—
14,000	020	07	280	06	40,000	270	35	250	33
15,000	340	09	(280)	(09)	41,000	270	32	—	—
16,000	290	13	280	13	42,000	270	36	—	—
17,000	280	18	—	—	43,000	260	38	—	—
18,000	290	22	290	20	44,000	260	35	—	—
19,000	290	21	—	—	45,000	250	38	250	39
20,000	280	24	300	23	46,000	230	45	—	—
21,000	280	29	—	—	47,000	250	40	—	—
22,000	280	29	—	—	48,000	260	36	—	—
23,000	280	30	280	31	49,000	250	35	—	—
24,000	270	35	—	—	50,000	240	31	240	25
25,000	270	36	280	38					
26,000	280	36	—	—					
27,000	270	33	—	—					
28,000	270	31	—	—					

NOTES:

a. Numbers in parentheses are estimated values.
b. Tropopause height was 35,000 ft MSL at H-hour.
c. Wind data were obtained from the Yucca weather station.
d. At H-hour the air pressure was 856 mb, the temperature 14°C, the dew point -3.6°C, and the relative humidity 31 percent.

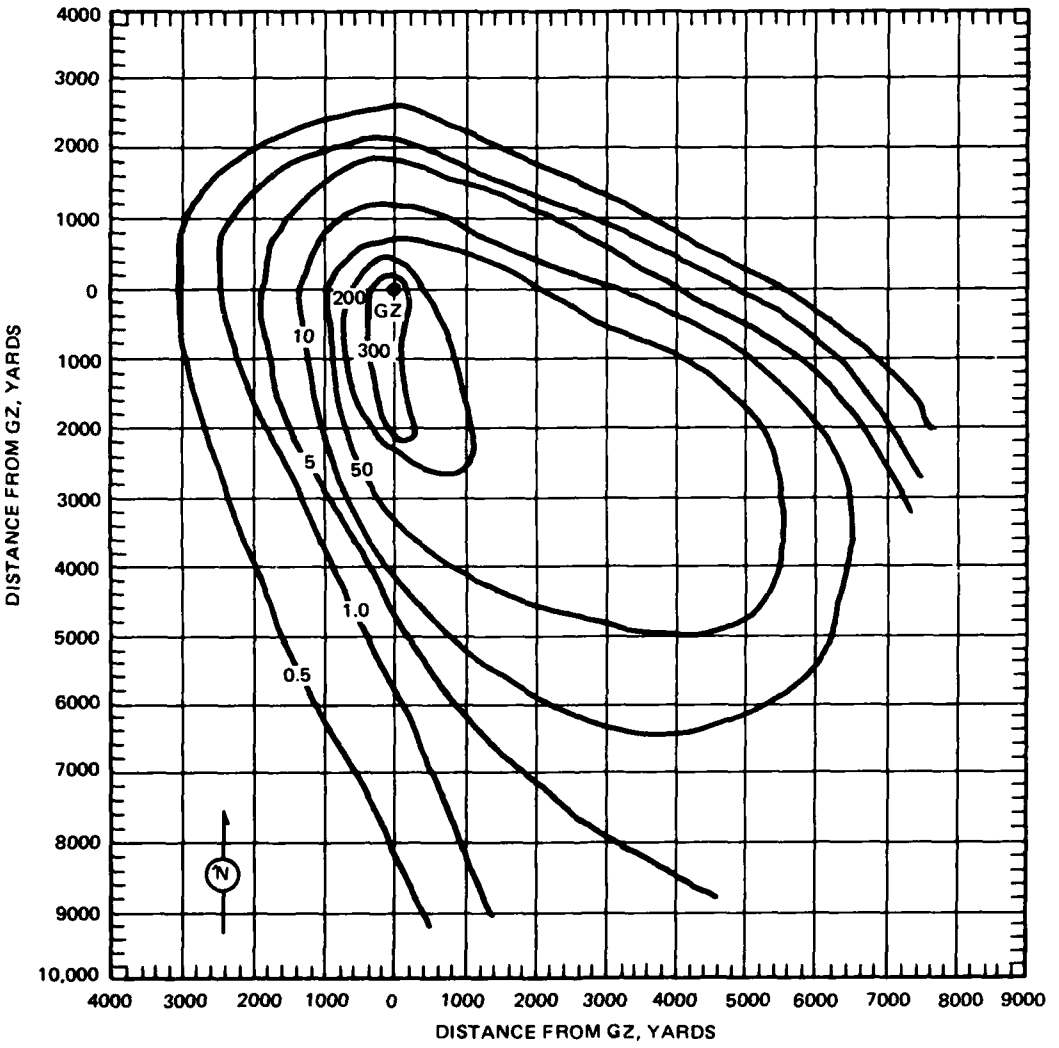

Figure 4-19. ONSITE DOSE RATE CONTOURS IN R/H AT H+1 HOUR FOR SHOT SMOKY.

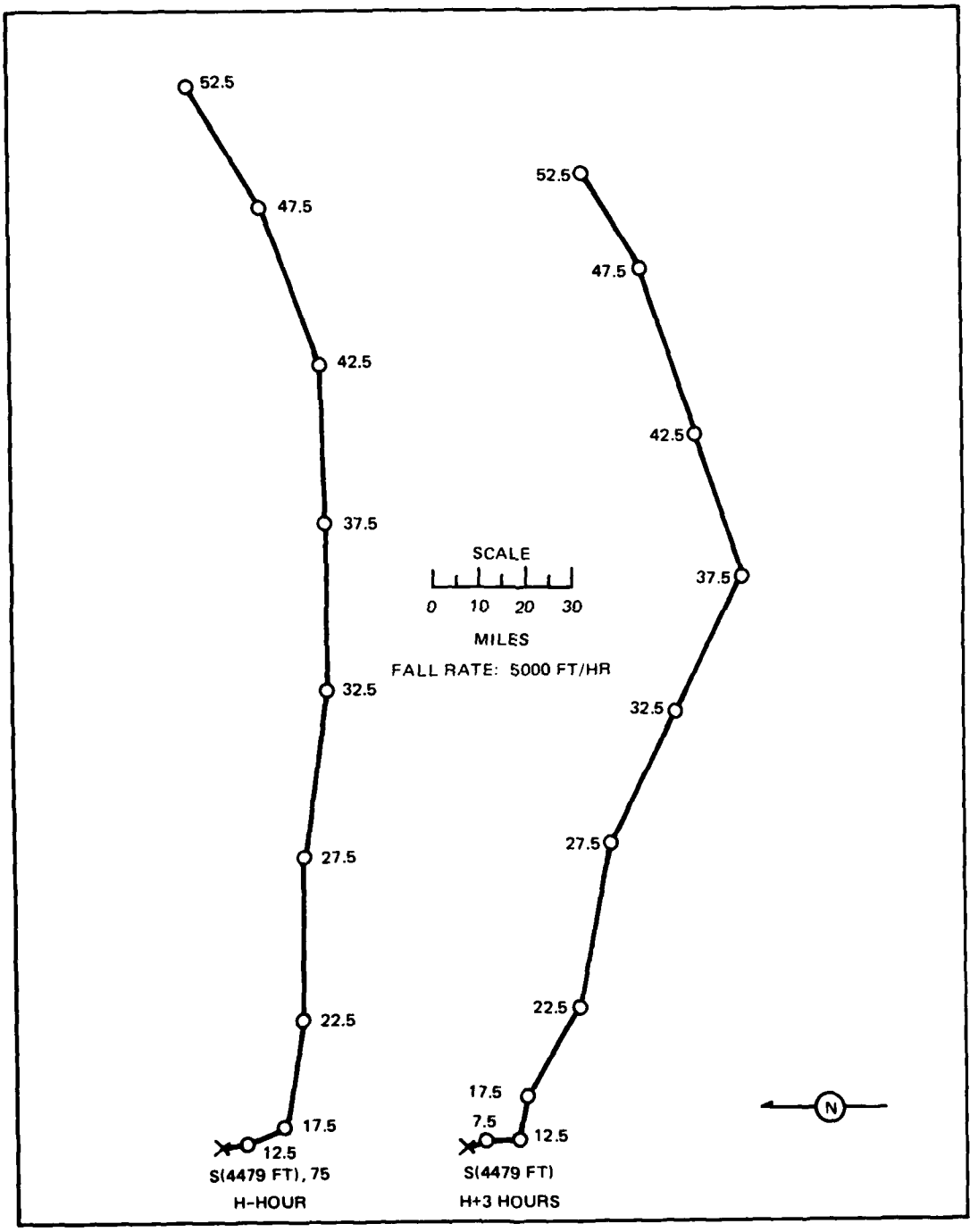

Figure 4-20. HODOGRAPHS FOR SHOT SMOKY.

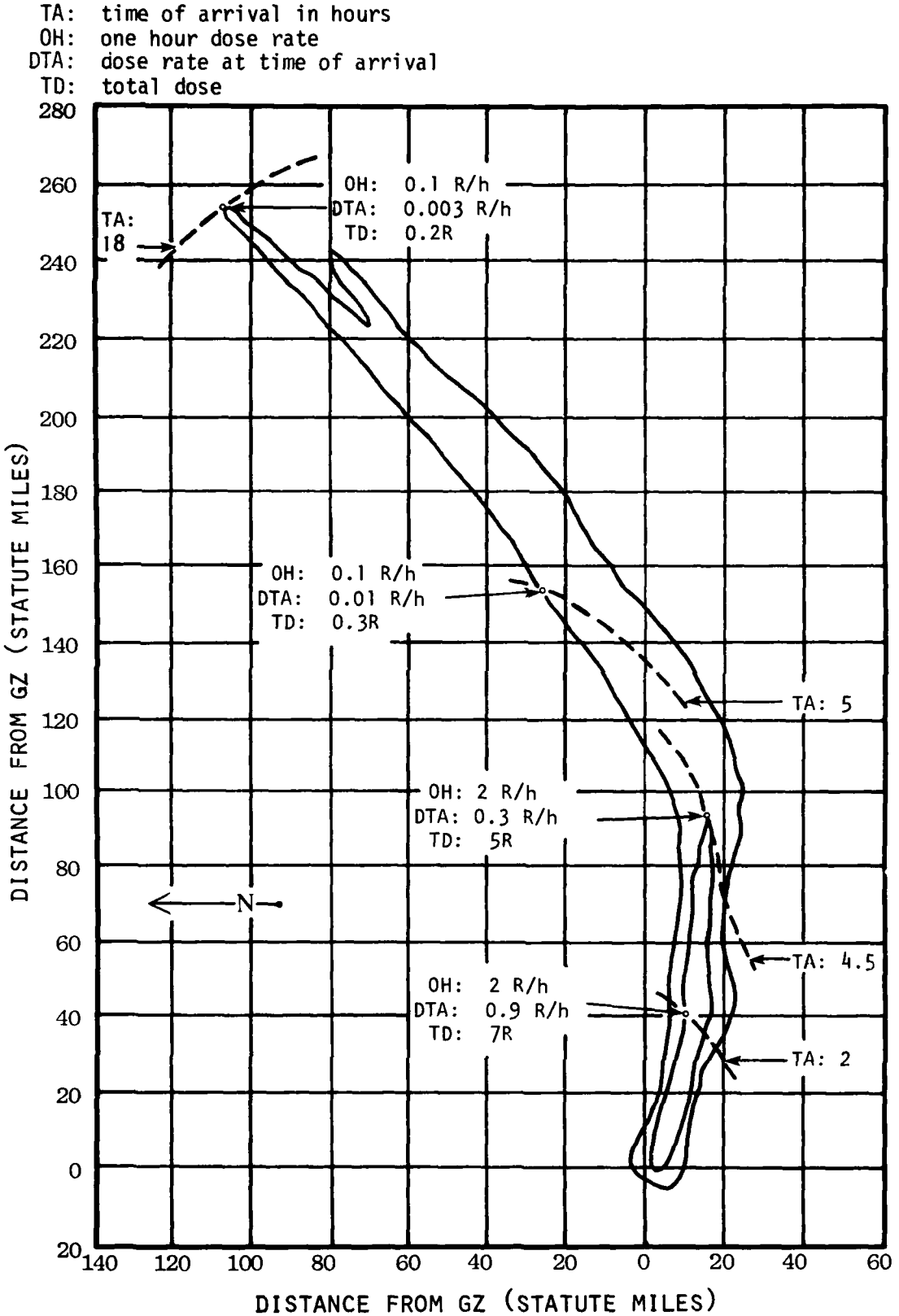

Figure 4-21. SHOT SMOKY OFFSITE CONTOURS.

forward areas was prohibited except as authorized by the AEC Test Director. After the shot, the Exercise Desert Rock Rad-safe Section maintained radiological situation maps, as did the AEC, showing isodose rate lines of 10 mR/h, 100 mR/h, and 1 R/h. Information plotted was provided by Desert Rock monitors and by AEC radiological safety personnel. For Exercise Desert Rock, however, the maps were located in the Rad-safe building at Camp Desert Rock, the 50th Chemical Platoon Decontamination Station at Yucca Pass, and the 50th Chemical Platoon Orderly room at Camp Desert Rock. In addition to their survey tasks, Desert Rock personnel used several means to limit exposure to the radiation. One method was to mark off restricted areas according to contamination measured. Desert Rock survey teams placed red cones connected by white engineer tape to mark the 5 R/h line. This area was strictly off limits to all Desert Rock personnel. The teams then surveyed to the 20 mR/h line and marked this area with yellow cones and engineer tape. Military police traffic control teams were posted to ensure that no buses or other ground vehicles passed beyond this 20 mR/h line (9;23).

In addition, Desert Rock Rad-safe survey teams monitored Camp Desert Rock on shot days to warn of impending fallout and to ensure that the cantonment area could be protected if wind shifts carried fallout in the camp's direction.

Any areas with dose rate values greater than 100 mR/h were called full radiological exclusion areas and were controlled. Entry into these areas required an access permit from the Rad-safe section. Check-points were established on access roads and were moved as the radioactivity decayed.

Radiological survey teams monitored the exposure of observers. Regardless of whether trenches or open observation areas were used, monitors watched the radiological situation and recommended moving, if necessary, to ensure the safety of participants. However, the trenches were not occupied. Observers later moved forward and reviewed the equipment which had been subjected to the effects of the weapon. To protect them, the monitor teams in jeeps first surveyed the routes and the display area to mark safe limits.

Pathfinder personnel also conducted radiological surveys; their efforts supported the troop maneuvers performed in connection with SMOKY. The Pathfinder teams, accompanied by a monitor from the Exercise Desert Rock Radiological Safety Section, flew into the maneuver area to determine whether the area was

radiologically safe. Radiological safety personnel stayed with the maneuver elements. The maneuver ended when the advancing troops reached points on the ground designated by the radiological safety personnel.

Desert Rock personnel wore regular uniforms during the Task Force WARRIOR Exercise (23). No specialized protective clothing was issued. Each man wore a field uniform and film badge and carried a protective mask. Some observers had dust respirators rather than a military protective mask. News media personnel were provided helmets, dust masks, and canteens. Because the observers at News Nob were 18 miles from the detonation, and Task Force WARRIOR personnel were at least eight miles from the detonation, protective masks were not required at detonation time.

4.6 NTO RADIOLOGICAL SAFETY

The Nevada Test Organization aerial and ground survey teams began taking measurements at about 0600 hours, one-half hour after the burst. The aerial survey team began to sweep toward the GZ area where they observed heavy fallout, starting about 2 miles from SMOKY GZ. The team observed large dust clouds in the ground zero area, which persisted for several hours. At the same time, the ground survey teams also began their measurements by proceeding along the radial roads leading to ground zero. As they neared ground zero, readings were unstable, and, as expected, showed increased amounts of contamination. The instability was due to fallout still coming down. Not until about 0900 hours were stable measurements made on some of the eight radial roads leading into GZ. Until then, readings were of no value since they changed minute by minute, and the contamination made the instruments unreliable. In addition, such exposure would have needlessly contaminated the monitors. Toward noon of D-day, the dust clouds subsided and the instrument readings became more stable. By approximately 1300 hours, the teams had completed their survey and had relayed information for the production of the initial radiation survey map showing isodose rate lines. The map (Figure 4-1) was used to establish a radiological exclusion area. Mid-time of the map is 1309 hours (H+8). (The mid-time of a radiation survey map is usually the halfway point between the starting time of the measurement and the completion time).

Personnel with access permits from the Test Director did not have to wait for isodose rate lines to be established before entering the ground zero

area. These personnel were equipped with anticontamination clothing and pocket dosimeters. Using the fragmentary and incomplete measurements already obtained in the aerial survey, they could roughly estimate the likely exposure they would receive in performing their recovery operation. By watching their pocket dosimeters, they could tell how closely their exposure was approaching the allowed limit. Thus, they were able to complete their recovery within safe limits or give it up and leave the area if it became clear they would exceed safe limits by continuing with their activities. After an isodose rate map became available, it was possible to make a much better estimate of exposure for a given mission in advance, and thereby make success of the mission relatively certain.

On D-day, a total of 34 parties consisting of 148 personnel were issued access permits which allowed them to enter forward areas (25). The number of anti-contamination items and dosimeters that were issued on 31 August and 1 September 1957, indicates extensive personnel activity in the forward areas. See Logistics Branch Activities, Section 4.3 (25).

In addition to surveying the shot area, the Rad-safe teams also surveyed the non-shot areas. They found no extensive fallout contamination at the normally used locations and traveled roads. In fact, on D-day, the air samples and fallout trays at most of these locations indicated a normal background. See Special Assignments Branch Activities, Section 4.3.

4.7 AFSWC RADIOLOGICAL SAFETY

AFSWC was subject to the AEC criteria for radiological safety (11). Because AFSWC air activities were based away from the NTS, REECo provided only advisory Rad-safe support, in addition to supplying film badges and reporting results. The organizational relationships for radiological safety among the various air groups are shown in Figure 4-2. Details about the primary Rad-safety and decontamination activities for each AFSWC project have not been found in any of the references cited. However, a personal communication with the former Executive Officer at Indian Springs Air Force Base provided information about some aircraft staging from that air base. The following sections detail that information.

4.7.1 Sampling Aircraft

In preparation for the sampling effort, the sampling equipment in four T-33, two F-84, and four B-57 sampling aircraft was loaded with filter paper. Pilots were briefed about flight paths prior to the shot, expected height of the radioactive cloud, penetration times into the radioactive cloud, and other aircraft they might encounter. The pilots took off early enough before the shot so that the planes were in position at H-1 hour. Relying on dosimeter readings, the pilots determined how many passes were necessary to obtain an adequate sample for use in radiochemistry tests. All pilots were on full internal oxygen before, during, and after cloud penetration. Pressure in the cockpits was normal, and no special filters were added to the air intakes. Upon completion of the sampling mission, the aircraft landed, taxied to the east taxi-strip, which was furthest from the operations area, and parked in a predetermined area. Although engines were shut down, the pilots remained on full oxygen, and the canopy remained closed and latched until the samples were removed from the aircraft. A sample removal team and radiological safety monitors then proceeded to the aircraft to remove samples and eventually to remove pilots from the aircraft. The sample removal teams first removed the filter paper from the aircraft, then placed these samples in shielded sample boxes. This entire operation was conducted with a forklift. After the oxygen was shut down and the canopies opened, the pilots were lifted out of the aircraft by forklift to ensure that they would not touch the outside of the aircraft. They were lifted into a pickup truck, which took them to the decontamination area. The truck then returned to pick up the samples and transfer them to sample return aircraft, which took the samples and couriers to Kirtland Air Force Base and other involved agencies such as the LASL, and UCRL laboratories.

Decontamination for both pilots and aircraft proceeded as follows: The pilots were monitored at the decontamination facility and then went through a complete decontamination (strip down, shower, etc.), even if no contamination was indicated. The clothing, a normal flight suit, was handled as necessary. The aircraft were decontaminated at the initial parking location. With the canopy closed, decontamination crews washed the aircraft externally with water from a firehose. The engines were started and firehose water was allowed to enter the engines. Waste water was allowed to soak into the desert off the taxi strip. Engines were shut down and the cockpit was wiped down internally, if necessary.

The aircraft was then returned to the flight line for maintenance in preparation for the next flight.

4.7.2 Helicopters

The following radiological safety procedures were used for helicopters which were expected to be flown through contaminated air space or landed on contaminated ground space. The interior of the helicopter was lined with plastic and masking tape at Indian Springs AFB primarily to avoid serious contamination of the aircraft by passengers who recovered materials and instruments on the ground in test areas during the mission. Plastic also was used to separate the pilot and passenger compartments and avoid contamination of the pilots and instrument panel. Otherwise, due to the complex and open nature of the helicopter's interior, decontamination, if necessary, would take two days to complete. Helicopter pilots and passengers participating in official reentries authorized by access permits were briefed at the NTS Control Point area area by REECo Rad-safe, just as other reentry parties were briefed prior to each test event. Passengers were instructed regarding anticontamination clothing and equipment to be worn. Prior to actual reentry, helicopters landed in the Control Point area and picked up a radiological safety monitor who assisted passengers in donning anticontamination clothing and who accompanied the mission. Pilots remained in regular flight attire and remained in the aircraft throughout the mission. During initial radiation surveys after each test event, helicopters did not land in test areas. Thus, contamination during these missions usually was slight and was on external parts of the aircraft.*

Helicopters landed at the Control Point area after their missions. Personnel then removed anticontamination clothing, were monitored, decontaminated (if necessary) at CP-2, and film badges were exchanged if doses greater than 100 mR were anticipated. The helicopters were monitored and washed down externally, if necessary. Plastic was removed from internal compartments only if monitoring indicated the need for decontamination to achieve the Nevada Test Site release limit of 7 mR/h beta plus gamma for fresh fission products.

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*This description provided by REECo participants.

4.7.3 Other Aircraft

Security sweep aircraft and helicopters which were not expected to penetrate contaminated air space used no special procedures other than film badging the pilots, crew, and passengers. Multi-engine aircraft operating from Kirtland AFB also had no special procedures except film badging.

4.8 GENERAL PERSONNEL GROUPINGS

Regardless of the organization to which an individual was administratively assigned, his possible exposure depended on the capacity in which he was physically operating at the time. For the purpose of this section, it is appropriate to discuss these activities as they relate to the three general groupings which follow:

- Scientific project personnel. This group includes personnel concerned with the placement, recovery and evaluation of experimentation conducted at SMOKY. Personnel involved were those assigned to the AEC design laboratories (UCRL, LASL, and Sandia), AFSWP personnel, and those Desert Rock personnel who were involved in the Technical Service and Air Operational Training Projects.

- Maneuver elements. This group includes the units conducting planned troop maneuver activities, and the transportation used in the assault; the requisite field support elements such as communications, military police, etc., to accompany the maneuver troops; and whatever observers, controllers, evaluators and Rad-safe personnel were required during maneuver activities in the NTS operational areas.

- Support Elements. This group includes all other personnel who were necessary to support the test, but were not required to go into the operational areas with the project personnel or maneuver elements.

4.8.1 Before the Detonation

- Scientific project personnel were involved in the layout, construction, equipment placement,

installation and dry runs for the scientific projects detailed in Chapters 2 and 3, and could have been exposed to ionizing radiation prior to shot SMOKY. Areas of the NTS were already contaminated by prior nuclear detonations and by earlier PLUMBBOB experiments. Although entry to Radex areas was controlled, residual radiation in non-Radex areas (less than 10 mR/h) could also have contributed to exposure over a period of time.

- Maneuver elements at SMOKY, which included Task Force WARRIOR and the HumRRO exercise (Task Force BIG BANG), required entry into operational areas at NTS for orientation, training and rehearsal purposes. Although these activities did not involve entry into any Radex area, there was an opportunity for exposure to low-level radiation from previous nuclear tests. Even though the HumRRO test was cancelled, rehearsals provided the opportunity for exposure prior to SMOKY. It should be noted that the troops needed to support the maneuver units during rehearsals included some personnel who were not a part of the actual maneuver itself, such as those necessary to support the digging of the defensive positions northwest of the surface ground zero.

- Support elements at Camp Desert Rock who did not go into the operational areas with either the maneuver elements or scientific project personnel had no opportunity for exposure to ionizing radiation other than background. However, some construction, transportation, communication and other logistical support personnel (who set up the facilities needed for the shot) entered the operational areas apart from the training or maneuver activities. Therefore, they had occasion for exposure.

4.8.2 Detonation Time

- Scientific project personnel on the ground were located outside a radius of eight miles from surface ground zero. None were exposed to initial radiation from the burst. Aircraft involved in air operational training and AFSWP projects were closer to the burst. Cloud sampler aircraft were 45-50 nautical miles (NM) east of ground zero, cloud tracker aircraft were about 50 NM southeast of ground zero, and Air National Guard aircraft were 30 NM south southwest of ground zero. None of the cloud sampler, cloud

tracker or National Guard crews were exposed to initial radiation from the burst.

- Maneuver elements were located outside a radius of eight miles from surface ground zero. None were exposed to initial radiation from the burst. Helicopter support aircraft were 25 NM south southwest of GZ.

- Support elements were all outside the eight-mile radius from surface ground zero. None were exposed to initial radiation from the burst.

4.8.3 After the Detonation

All the numbered operational areas around ground zero were closed until it was determined that controlled access to the shot-area could be re-established (R-hour). However, at SMOKY no specific R-hour was noted. Notes from LASL operational logs indicate that by H+7 hours, Areas 1,2,4 and 12 were open. Areas 3 and 7 were closed for the remainder of D-day and Area 9 was closed until 3 September 1957.

- Scientific Project Personnel. The LASL notes state that by H+7 hours the UCRL (diagnostic) data had been recovered, which indicates that there was some limited entry into the shot area. However, closure of Areas 3,7 and 9 means that there were no other entries to those areas on D-Day. Subsequent to D-Day, the scientific project personnel had recurrent opportunities for exposure to ionizing radiation depending on the number of entries required to gather data or recover equipment.

- Maneuver Elements. The Pathfinder Unit from Task Force WARRIOR was in the maneuver objective area by H+7 minutes. At H+1.75 hours, the first elements of Task Force WARRIOR arrived at assault positions. Although these troops did not enter the downwind fallout areas, exposure to upwind fallout was possible in addition to exposure to contamination from previous tests. When the Rad-safe monitors who accompanied the troops determined that each maneuver element had advanced to its limit (according to the radiological situation at 0915 hours), the exercise was terminated. It is probable that the radiological limits were those for a limited Radex area (10 mR/h.) Entry into such areas required protective clothing. Troops from the

maneuver elements were also involved in subsequent entries into the area to recover equipment, inspect defensive positions and visit the display areas; these entries provided recurrent opportunity for exposure.

- Support Elements. These personnel did not enter the downwind fallout areas (3,7 and 9) on D-Day although activities associated with the maneuver elements and scientific project personnel did require exposure of some of the support elements in other operational areas. One example was the ground transportation required to remove maneuver elements following the exercise. After D-Day, such support elements as construction engineers and signal personnel had recurring opportunity for exposure when they entered the Nevada Test Site areas to recover support equipment.

4.9 ANALYSIS OF EXPOSURES, DESERT ROCK PERSONNEL

Examination of two preliminary compilations, the Department of the Army (18) and REECo (26) shows the listing of the members of many military units at Desert Rock by unit and by their radiological dose (as recorded by the film badge worn). With this information, the mean dose and its standard deviation can be determined for each unit. Because the individuals involved were issued several film badges, one at a time, to cover their total stay at Desert Rock, the approximate time periods during which the doses were received can be determined. The time picture is only approximate because badges were not necessarily issued on the same day to all members of a given unit, nor were they turned in on the same day. Bearing this imprecision in mind, one may determine mean unit doses for three periods of time as follows:

- Period I: Before SMOKY - All film badges with final dates before or on August 30, 1957.
- Period II: During SMOKY - All film badges with initial dates before August 31, 1957 and final dates after August 31, 1957 (to include badges with 31 August 1957 as both initial and final date).

- Period III: After SMOKY - All film badges with initial dates on or after September 1, 1957.

The results for 42 Desert Rock military units are shown in Table 4-8. For each unit during the periods of time defined above, the Table gives the number of personnel in the unit with a significant recorded dose*, N, the mean dose for the personnel, μ and the standard deviation σ of the dose. For Period II, during SMOKY, we show in addition the total number of personnel in the unit during this period, N_t.

Column I in Table 4-8 denotes information deduced from film badges with final dates prior to 30 August 1957. Column II signifies information deduced from film badges with dose readings covering 31 August 1957; and Column III indicates information derived from film badges with starting dates on, or subsequent to, 1 September 1957. (Note that N_t is actually determined for Column II only).

Examination of the mean doses in Table 4-8 leads to two conclusions (explained below) regarding the distribution of doses in the group of individuals who made up the 42 Desert Rock military units being considered. This group totaled some 3000 persons during Period I, a comparable number for Period II, and substantially less for Period III, since many left after SMOKY.

The first conclusion is that during Period I, Desert Rock personnel received a dose comparable to the dose received during Periods II and III combined. This is clear from Table 4-9 which shows the total person-rem accumulated and then overall rem/person for the periods.

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*In calculating mean doses and standard deviation of doses, only doses greater than 100 mR have been considered to be significant. This definition of a "significant recorded dose" as being above 100 mR is somewhat arbitrary. It is intended to exclude badge data which indicate either no exposure or minimal exposure in the forward areas. Also, there are uncertainties regarding exposure to natural and other low sources of radiation not related to weapons testing, uncertainties in film quality, and the like.

Table 4-8. TABULATION OF UNITS VS. THE VALUES OF N_t, N, μ, AND σ

UNIT	N_t	N			(μ) MEAN (mr)			STAND. DEVIATION (mr) σ		
		I	II	III	I	II	III	I	II	III
EXERCISE DIRECTORS' STAFF										
FINANCE	7	1	–	–	108	–	–	–	–	–
S-2 SECTION	4	1	–	–	143	–	–	–	–	–
S-3 SECTION	13	6	9	1	1139	593	295	698	316	–
S-4 SECTION	27	5	2	–	655	202	–	620	10	–
INSTRUCTION GROUP	6	3	4	3	1463	345	916	384	411	955
EXERCISE AVIATION SUPPORT										
3RD TRANS BN (HELICOPTER)	38	5	8	–	124	286	–	16	278	–
31ST TRANS CO (HELICOPTER)	128	1	40	1	600	535	106	–	603	–
TECHNICAL PROJECTS										
PROJECT 50.3	29	1	3	5	330	226	283	–	152	226
PROJECT 50.8	130	103	94	9	1185	240	674	855	114	1324
HUMRRO/82D ABN PROV. CO										
PROV CO 82D ABN	175	5	150	2	1683	1456	638	1250	844	7
HUMRRO	6	–	5	–	–	1754	–	–	1470	–
CAMP DESERT ROCK EVAL GRP.	19	10	13	–	249	243	–	83	130	–
SPECIAL STAFF										
HQ CMDT	93	8	19	2	714	432	272	771	344	108
37TH MED DET	1	–	1	–	–	220	–	–	–	–
S-1 STAFF JUDGE ADVOCATE	4	1	2	–	361	220	–	–	220	–
AG SECTION	17	10	2	–	217	120	–	160	7	–
PUBLIC INFORMATION OFFICE	13	1	2	–	145	150	–	–	64	–
SPECIAL SERVICES	5	5	–	–	133	–	–	11	–	–
PROVOST MARSHALL	8	3	–	–	120	–	–	14	–	–
POST SIGNAL	12	1	1	–	100	133	–	–	–	–
CAMP QUARTERMASTER	8	3	–	–	132	–	–	29	–	–
CAMP ENGINEER	10	2	1	–	142	170	–	59	–	–
MANEUVER UNITS										
1ST BATTLE GRP, 12TH INF	554	466	414	–	409	279	–	141	291	–
PATHFINDER TEAM	14	14	13	–	1394	309	–	501	259	–
PROJ 50.1	170	32	39	–	120	569	–	26	1061	–
OBSERVERS/VISITORS										
VISITORS BUREAU	270	1	122	–	271	290	–	–	176	–
SUPPORT TROOPS										
US ARMY GARRISON, DET 3	69	26	4	–	173	123	–	115	10	–
POSTAL	5	4	–	–	134	–	–	22	–	–
CO B 84TH ENGR BN	79	28	7	–	359	632	–	425	313	–
1ST HOSP UNIT/8TH FLD HOSP	52	20	12	–	412	531	–	293	514	–
293RD MP CO	91	48	27	–	419	236	–	–	–	–
232D SIGNAL CO	351	161	86	3	244	697	150	250	1580	87
2ND SIGNAL PHOTO PLATOON	21	2	9	7	372	297	1442	140	162	810
DOSIMETRY TEAM	4	1	1	–	1260	140	–	–	–	–
50TH CHEMICAL PLATOON	76	69	28	16	975	474	674	959	712	398
26TH TRANS BN (TRUCK)	61	15	12	–	623	260	–	578	396	–
38TH TRANS CO (S&P)	92	70	34	4	415	233	425	278	207	228
2D TRANS CO (MED TRK)	86	64	8	1	344	138	250	267	25	–
531ST TRANS CO (MED)	103	46	9	–	274	257	–	210	310	–
53RD QM DETACH (SUB SPT)	52	11	1	–	133	100	–	48	–	–
PROV AVN DETACH (AVN SEC)	25	9	3	–	176	133	–	63	27	–
526TH ORD CO (HAM)	120	35	5	18	603	195	1095	610	42	543

N_t = TOTAL NUMBER OF PERSONNEL IN A UNIT ISSUED FILM BADGES COVERING 31 AUGUST 1957

N = NUMBER OF PERSONNEL WITH A DOSE ACCUMULATION GREATER THAN OR EQUAL TO 100 mr

(μ) MEAN (mr) = MEAN ACCUMULATED DOSE IN mr FOR DOSES GREATER THAN OR EQUAL TO 100 mr

(σ) STANDARD DEVIATION (mr) = STANDARD DEVIATION OF ACCUMULATED DOSE IN mr FOR DOSES GREATER THAN OR EQUAL TO 100 mr

Table 4-9. PERSON-REM AND MEAN MREM/PERSON FOR DESERT ROCK PERSONNEL.

Period	I	II	III
N	1297	1187	72
Total person-rem	625	582	56
Mean mrem/person	482	490	778

In summary, the total dose for Task Force Warrior (1st Battle Group) prior to SMOKY was larger than that during and after SMOKY. (See Table 4-8 for the 1st Battle Group.)

The second conclusion from Table 4-8 is that the exposures to the persons in a given unit (at this organizational level) are not homogeneous. If a group of people entered a contaminated area and if they spent substantially the same time at various locations, then the resulting doses would be expected to distribute in the familiar bell-shaped normal distribution about the mean dose. Examination of the dose distribution* within groups shows, however, that these distributions are far from normal. The same fact is illustrated by the large values of the standard deviations relative to the averages in Table 4-8. Thus, the individuals within a unit seem to have widely scattered exposure histories for these three periods. Exposures also may not be homogeneous because individuals performed separate functions in groupings smaller than the units listed in Table 4-8.

4.10 TASK FORCE WARRIOR ANALYSIS

The radiation exposures to Task Force WARRIOR, the major troop element at shot SMOKY, were reconciled through analytical techniques (10). The analysis includes the refinement of existing fallout contours, estimation of all

*Dose distributions were plotted for each unit. These are not reproduced here since, other than the qualitative feature of non-normality, they are of limited interest.

significant troop activities in the forward area, calculation of incremental and total exposures from both initial and residual radiation, and a conversion of exposures to film badge equivalence in order to compare them with dosimetry data. Uncertainties are determined for all the variables in order to establish overall confidence limits.

The activities of Task Force WARRIOR, a reinforced infantry company from the 1st Battle Group, 12th Infantry, are traced from rehearsals and other pre-shot activities in early August (including observation of other shots), through the full-scale operation on 31 August and the subsequent operational tasks. The scenario thus developed provides the time-dependent position data required for an exposure analysis. Where available data are insufficient to determine precise times and durations of activities, reasonable assumptions are used to establish a complete and logical scenario, based in some instances on standard Army practices. Uncertainties in spatial or time-dependent data are factored into the error analysis. Significant troop activities of Task Force WARRIOR were determined to be the following:

1. Rehearsals of the troop maneuver plan, including alternate plans developed to consider various fallout contingencies for shot SMOKY.

2. Preparation of defensive positions near SMOKY ground zero to provide experience factors for Army planning and doctrine purposes. Positions would not be occupied, but would be inspected after the shot to assess the damage.

3. Observation of shot DOPPLER from trenches located about 2850 meters from ground zero, beyond the minimum safe distance established by the Continental Army Command.

4. Helicopter movement of a landing force to an objective area and subsequent ground assault of a terrain objective immediately following the SMOKY detonation. Concurrent with the ground assault, the task force was resupplied utilizing helicopter transport of consumables. The entire exercise was planned to demonstrate the ability of the task force to operate on an atomic battlefield.

The initial and residual radiation from all shots to which the task force was exposed is calculated or derived from available intensity measurements. The synthesis of intensity and decay rate data for fallout fields permits the dose

rate to be determined for any position and for any time. Applying the time and space factors to the radiation environment results in dose estimates for each of the activities conducted by the task force. A rigorous uncertainty analysis for all parameters provides confidence limits for the dose estimates, while providing a sound basis for summing the doses from each activity. The calculated free-field doses are then adjusted to reflect the dose that a film badge, as usually worn, would record in the same environment.

Concurrently, film badge data for Task Force WARRIOR was obtained by direct examination of Army records. Although there were some badges that are not included in the statistical analysis because of inconsistencies or lack of uniformity in the badge issue periods, more than 90 percent of the film badges are used to evaluate badge readings relative to their period of issue. The statistics indicate that most of the task force engaged in similar activities during its six-week stay at the test site. A small, discrete group of 20 men, however, accrued an appreciably larger film badge dose (average of 1.1 rem) than the remainder of the unit in the period that includes the SMOKY shot itself. Excluding this group, the mean film badge reading determined from the original data was less than 0.6 rem. The calculated free-field troop doses, adjusted to reflect film badge equivalence, are compared with the analyzed film badge data for the major badge issue periods. The correlation is quite high for troop activities in residual radiation fields. Correlation of calculated and film badge doses for initial radiation exposures is not conclusive because the film badges were insensitive to the neutrons from shot DOPPLER and because the film badges were shielded by troops as they crouched in the trenches. The major conclusions of the analysis are as follows:

- The sources of radiation exposure to the troops of Task Force WARRIOR were primarily from shots preceding SMOKY. The sources of residual radiation were from the fallout of several shots conducted in Yucca Flat. The source of initial radiation was shot DOPPLER, which the task force observed on 23 August.

- Integrated film badge doses, as calculated from the troop scenario and the reconstructed radiation environment, are 480 $\pm$ 135 mrem. This dose correlates with the actual mean total film badge reading of 575 mrem as determined from the complete original film badge data.

- The total mean free-in-air dose to troops, considering all radiation sources, was 970 ± 270 mrem. This value is larger than film badge readings primarily because of shot DOPPLER, where troop neutron exposure was not recorded on the film badges and where film badges were body-shielded. The total dose, in the unit as summed above, is not correlated with specific biological effect.

- The spatial and temporal distribution of troop activities leads to a distribution of calculated doses. This distribution displays an upper dose limit of over twice the mean calculated dose. Excluding a small group whose film badge dose of approximately 1100 mrem during a five-day period indicated a unique activity, the calculated upper limit exceeds the actual film badge readings in almost all cases. This demonstrates the consistency of troop activities with resultant film badge doses and provides a reasonable limit of 1100 mrem (film badge equivalence) for overall assessment of the radiation exposure.

APPENDIX A

August 24, 1957

SCHEDULE OF EVENTS (34)*
D-1 Day

ITEM NO.	HOUR	AGENCY	EVENT
1	0930	Test Group	Test Group Directors will make final reports of readiness status of their programs to the Test Director, including considerations for execution or postponement of this event.
2	1100	Manned	Program Directors will furnish Plans and Operations (S-3) names of persons to be at manned stations at H-Hour and information on communications and safety arrangements.
3	1600	Test Manager	Weather briefing for Test Manager, Scientific Advisor, Advisory Panel, Test Director, and others who have been invited to attend by Test Manager, will be conducted in Mercury, Bldg. 101.
4	1700	34.2	Contractor will close each sta. chamber, sandbag sta. entrance
5	1830	33.2, 33.3 33.5	9 men, 4 veh. Accomplish placement and button-up activities at Program 33 stas. located on the N, N42° E and South blast lines.
6	1900	Security	Begin muster badge issue and logging of personnel through Gate 4 (Mercury Hwy. and Yucca Lake Road) into forward area.
7	1900	2.3, 39.5	3 men, 1 veh. Proceed to Area 2c to complete installation of instrumentation.
8	2100	34.2	Button-up Stas, 8-34.2-8017.01 and 8-34.2-8017.02
9	2100	34.3	Button-up Stas. 8-34.3-8018.01 and 8-34.3-8018.02

* This schedule for the SMOKY event is extracted from the operation order containing all schedules for PLUMBBOB events. It was prepared prior to SMOKY but reports indicate it was carried out as planned.

APPENDIX A
(Continued)

August 24, 1957

SCHEDULE OF EVENTS
D-1 Day

ITEM NO.	HOUR	AGENCY	EVENT
10	2130	8.3b	2 men, 1 veh. Proceed to Smoky Tower to connect timing wires.
11	2200	Test Manager	Weather outlook meeting in Conference Room. Bldg. 101, by Staff Weather Officer, Test Manager, Scientific Advisor, Advisory Panel, Test Director, and invitees.
12	2200	Security	Security sweep detail will depart Gate and begin final sweep of test area. Clear area by 0230.
13	2200	2.3, 39.5	Party clear area.
14	2400	Security	No private vehicles will be allowed to pass through Gate 2 into the test area until H+5 min.
15	2400	33.2. 33.3 33.5	Party clear area.

APPENDIX A
(Continued)

August 24, 1957

SCHEDULE OF EVENTS
D-Day

ITEM NO.	HOUR	AGENCY	EVENT
1	H-5 hrs	9.1	8 men, Net #1, Hilltop 21 & 83, Phone 8135. Establish manned photo sta. at the "Y", BM 4076.
2	H-5 hrs	64.2	1 man, 1 veh. Check telemetering package and set up for remote operations at shot cab. Will then proceed to Sta. 311 reporting to A-3 upon arrival.
3	H-5 hrs	Arming	10 men, 5 veh. Net #6. Arming and EG&G representatives leave CP for Sta. 353, arriving at 0100, (balance of party proceeds directly to T-2c or have previously arrived). Leave Sta. 353 at 0115 and arrive T-2c at 0130. Arming complete by 0245. Salvage started by 0300. Salvage complete and depart depart T-2c at 0315. Arming and EG&G representatives arrive at Sta. 353 by 0330, (balance of party proceeds directly to Gate 4 or other destinations). Arming and EG&G representatives arrive CP by 0400.
4	H-3 hrs	BPU and Micro-baragraph	3 men, 2 veh. Two HE shots, 1.2 tons areas 4-247a and 4-247b, 6 mi. SW of GZ.
5	H-2 1/2	64.2	10 men, 4 veh. Net #8, Phone 8367. Proceed to Sta. 311 and man through shot time and all next working day if permitted by Rad-Safe.
6	H-2 hrs	Security	Security will report to Test Manager and Test Director that the test area north of Gate 4 is clear of all personnel except those in approved manned stations.

APPENDIX A
(Continued)

August 24, 1957

SCHEDULE OF EVENTS
D-Day

ITEM NO.	HOUR	AGENCY	EVENT
7	H-2 hrs	Test Manager	Final weather briefing for Test Manager, Test Director, Scientific Advisor, Advisory Panel, and others who have been invited to attend by Test Manager, will be conducted at CP 1.
8	H-2 hrs	Desert Rock	650 troops will clear Gate 4 and proceed to trenches (E851-N128) and remain through shot time.
9	H-2 hrs	21.3	8 men. Depart Project 21.3 launching pad for CP.
10	H-1 1/2 hrs	LASL	10 men, Net #5, Phone 8363. Proceed to Sta. 311 to man through shot time.
11	H-1 hr	ALL	Gate 2 (check station 2 mi. north of Mercury) will be closed to all northbound traffic except emergency traffic which will be cleared with the Test Director's S-3 section (phone 8281) for approval to pass through Gate 2. Gate 2 will be opened to northbound traffic after shot upon notification from Test Director's office
12	H-1 hr	9	Documentary aircraft will orbit at 9000' MSL, 11 nautical miles S of GZ, in a right hand pattern. Will be on a heading of 90°T at H-Hour. Loudspeaker announcement of H-30 min.
13	H-30 min	ALL	All unnecessary electrical equipment will be turned off including razors and vehicle ignitions.
14	H-30 min	17.1	3 men, 2 veh. Net #5. Man Sta. G-17-5002 on East Shore of Yucca Lake through shot time.

APPENDIX A
(Continued)

August 24, 1957

SCHEDULE OF EVENTS
D-Day

ITEM NO.	HOUR	AGENCY	EVENT
15	H-15 min	ALL	All radio transmitters, automobile motors, electric shavers, and other sources of radio interference will be shut off until after H-Hour except for radio frequencies authorized in this annex. Electric shavers should not be used in the CP area until at least 2 hours after the shot, and it is preferred that they not be used at any time on D-Day.
16	H-10 min	ALL	Siren on CP Bldg. will be turned on for 30 sec.
17	H-10 min	ALL	Red lights on CP Bldg. will be turned on until after H-Hour.
18	H-5 min	ALL	Loudspeaker announcement that it is now H-Hour minus 5 min. All persons without density goggles will be warned to turn their backs to the blast and not turn around until after initial flash.
19	H-1 min	ALL	PA announcement of H-1 min and reminder to put on density goggles or face away from the blast.
20	H-Hour	ALL	Zero time for detonation.
21	H+5 min	REECo Rad-Safe	6 men, 3 veh. Initial survey party for areas, 1,2,3,4,7,9, and 12. Check areas other than shot areas for contamination.
22	H+5 min	REECo	14 men, 7 veh. Initial survey party and Rad-safe check sta. personnel. Area T-2c and north run of Mercury Hwy to Area 13.
23	H+5 min	39.5	7 men. Recover neutron and gamma ray detectors from 3000' cable running south from GZ.

APPENDIX A
(Continued)

August 24, 1957

SCHEDULE OF EVENTS
D-Day

ITEM NO.	HOUR	AGENCY	EVENT
24	H+5 min	2.3	5 men, 1 veh. Proceed to point 4000' from GZ to pull instrument cable and remove instruments.
25	H+5 min	2.3	4 men, 1 veh. Proceed to point 3400' from GZ to pull out instrument cable and remove instruments.
26	H+15 min	REECo	3 men. Initial airborne radiological survey of Area T2c, and other areas. Flight will cover test points designated by the Test Director and sweep other areas.
27	H+30 min	9.1	Party clear area.
28	H+1 hr	23.1	6 men, 2 veh. Recover film at Sta. 2-380, 25000' SW of GZ.
29	H+1 hr	22	7 men, 2 veh. Recover film at Sta. 2-300, 4.5 mi. SW of GZ.
30	H+1 hr	22.1	5 men, 2 veh. Open doors at Sta. 2-300, 4.5 mi. SW of GZ.
31	H+1 hr	21.3	3 men. Depart in L-20 to NE of Area 2c to locate rocket nose cone.
32	H+1 hr	21.3	3 men. Depart via helicopter to NE of Area 2c to recover rocket nose cone
33	H+1 hr	39.5	4 men. Helicopter recovery of neutron detectors 1700 yds N of GZ.
34	H+1 hr	30.6	5 men, 2 veh. 30.7 Initial cursory damage survey of various stas. for H+6 hr. report. Time in area 30 min.

APPENDIX A
(Continued)

August 24, 1957

SCHEDULE OF EVENTS
D-Day

ITEM NO.	HOUR	AGENCY	EVENT
35	H+1 hr	CETG Director	4 men, 1 veh. Proceed to T-2c access road to inspect damage to structures and CETG stas. located on either side of road. Time in area 30 minutes.
36	H+1 hr	35.4	4 men, 1 veh. Proceed to series of stas. along Fallout path to measure gamma intensity. Time in area 1 hour.
37	R-Hour	ALL	Test Director will announce that recovery operations may begin as scheduled. Test personnel and security branch will be informed.
38	R-Hour	EG&G	2 men, 1 veh. Film recovery at various stas.
39	H+3 hrs	35.2	4 men, 2 veh. Two decontamination teams to Brock Houses outside 3 mi. range from GZ.
40	H+3 hrs	35.3	2 men. Helicopter flight over pre-selected survey range area T-2c.
41	H+3 hrs	35.3	2 men, 1 veh. Radiation survey of area around T-2c. Time in area 1 hr.
42	H+4 hrs.	35.3	2 men, 1 veh. Vehicle radiological survey at speeds of 5, 10, 20, and 40 mph if possible. Time in area 2 hrs.
43	H+5 hrs	35.3	2 men. Helicopter flight over pre-selected survey range area T-2c.
44	H+5 hrs	35.3	2 men, 1 veh. Radiation survey of range near area T-2c. Time in area 1 hr.

APPENDIX A
(Continued)

August 24, 1957

SCHEDULE OF EVENTS
D-Day

ITEM NO.	HOUR	AGENCY	EVENT
45	H+6 hrs	REECo	3 men. Airborne radiological resurvey of area T-2c and other areas. Flight will cover test points designated by the Test Director and sweep other areas.
46	H+8 hrs	33.1,33.2, 33.3	14 men, 4 veh. Photography, post-shot button-up of equipment and recovery of data at Program 33 stas. located on the S, N42°E, and N Blast Lines.
48	H+9 hrs	35.3	2 men, 1 veh. Radiation survey of range near area T-2c. Time in area 1 hr.
49	H+9 hrs	35.3	2 men. Helicopter flight over pre-selected survey range area T-2c. Time in area 2 hrs.

REFERENCE LIST

The following list of references represents only those documents cited in the SMOKY volume. A complete list of all documents consulted during the preparation of the PLUMBBOB shot volumes is contained in the PLUMBBOB series volume.

AVAILABILITY INFORMATION

An availability statement has been included at the end of the reference citation for those readers who wish to read or obtain copies of source documents. The following addresses are being provided for that purpose.

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Naval Surface Weapons Center
ATTN: Library

Naval War College
ATTN: Professor & Libraries

Naval Weapons Center
ATTN: Code 233, Tech Library

Naval Weapons Evaluation Facility
ATTN: Library

Navy Dept Library
ATTN: Librn

Navy Nuclear Power School
Department of the Navy
ATTN: Library

Navy Nuclear Test Personnel Review
2 cy ATTN: W. Loeffler

U.S. Naval Academy
Nimitz Library
ATTN: Documents & Reports Dept

DEPARTMENT OF THE NAVY (Continued)

Office of the Judge Adv Gen
Department of the Navy
ATTN: Code 73

U.S. Marine Corps Cmd & Staff College
ATTN: Library

U.S. Merchant Marine Academy
ATTN: Librn

U.S. Naval Air Station Library
Department of the Navy
ATTN: Library

DEPARTMENT OF THE AIR FORCE

Academy Library DFSELD
U.S. Air Force Academy
ATTN: Library

Aerospace Defense Command
ATTN: Historian

Air Force Communications Service
ATTN: Historian

Air Force Institute of Technology
ATTN: Library

Air Force Logistics Command
ATTN: Historian

Air Force Nuclear Test Personnel Review
ATTN: HQ USAF/SGES

Air Force School of Aerospace Medicine
ATTN: Strughold Library

Air Force Systems Command
ATTN: Historian

Air Force Technical Applications Center
ATTN: Historian

Air Force Weapons Laboratory
Air Force Systems Command
ATTN: Tech Library

Air National Guard
ATTN: Historian

Air Training Command
ATTN: Historian

Air University Library
Department of the Air Force
ATTN: AUL-LSE

Military Air Lift Command
ATTN: Historian

Commander in Chief
Pacific Air Forces
ATTN: Historian

Strategic Air Command
Department of the Air Force
ATTN: NRI-STINFO Library
ATTN: Historian

DEPARTMENT OF THE AIR FORCE (Continued)

Tactical Air Command
Department of the Air Force
ATTN: Historian

U.S. Air Force Occupational & Env Health Lab
ATTN: NTPR

DEPARTMENT OF ENERGY

Department of Energy
ATTN: OMA

Department of Energy
Nevada Operations Office
ATTN: Health Physics Div
ATTN: R. Nutley

Department of Energy
Human Health & Assessments Division
ATTN: EV-31

OTHER GOVERNMENT AGENCIES

Centers for Disease Control
U.S. Public Health Service
ATTN: G. Caldwell

Central Intelligence Agency
ATTN: Office of Medical Services

Department of Health & Human Svcs
ATTN: Office of General Counsel

Management & Budget Off Library
ATTN: Librn

Library of Congress
ATTN: Library Service Division
ATTN: Science & Technology Div
ATTN: Serial & Govt Publication

National Atomic Museum
ATTN: Historian

Department of Commerce
National Bureau of Standards
ATTN: Librn

National Technical Information Service
12 cy ATTN: Customer Services

Occupational Safety & Health Admin
ATTN: C. Wright

Office of Health & Disability (ASPER)
ATTN: R. Copeland

Ofc of Workers Compensation Program
Department of Labor
ATTN: R. Larson

U.S. Coast Guard Academy Library
ATTN: Librn

U.S. House of Representatives
ATTN: Committee on Armed Svcs

OTHER GOVERNMENT AGENCIES (Continued)

U.S. House of Representatives
Committee on Interstate & Foreign Commerce
ATTN: Subcommittee on Health & Envir

U.S. Military Academy
ATTN: Director of Libraries

U.S. Senate
Committee on Armed Services
ATTN: Committee on Veterans Affairs

U.S. Senate
ATTN: Committee on Veterans Affairs

Veterans Administration-RO
Providence, RI
ATTN: Director

Veterans Administration-RO
Montgomery, AL
ATTN: Director

Veterans Administration-RO
Juneau, AK
ATTN: Director

Veterans Administration-RO
Anchorage, AK
ATTN: Director

Veterans Administration-RO
Phoenix, AZ
ATTN: Director

Veterans Administration-RO
Little Rock, AR
ATTN: Director

Veterans Administration-RO
Los Angeles, CA
ATTN: Director

Veterans Administration-RO
San Francisco, CA
ATTN: Director

Veterans Administration-RO
Denver, CO
ATTN: Director

Veterans Administration-RO
Hartford, CT
ATTN: Director

Veterans Administration-RO
Wilmington, DE
ATTN: Director

Veterans Administration-CO
Washington, D. C.
ATTN: Dept Veterans Benefit, Central Ofc
ATTN: Director
ATTN: Board of Veteran Appeal

Veterans Administration-RO
St. Petersburg, FL
ATTN: Director

OTHER GOVERNMENT AGENCIES (Continued)

Veterans Administration-RO
Atlanta, GA
ATTN: Director

Veterans Administration-RO
Honolulu, HI
ATTN: Director

Veterans Administration-RO
Chicago, IL
ATTN: Director

Veterans Administration-RO
Seattle, WA
ATTN: Director

Veterans Administration-RO
Indianapolis, IN
ATTN: Director

Veterans Administration-RO
Des Moines, IA
ATTN: Director

Veterans Administration-RO
Wichita, KS
ATTN: Director

Veterans Administration-RO
Louisville, KY
ATTN: Director

Veterans Administration-RO
New Orleans, LA
ATTN: Director

Veterans Administration-RO
Togus, ME
ATTN: Director

Veterans Administration-RO
Baltimore, MD
ATTN: Director

Veterans Administration-RO
Boston, MA
ATTN: Director

Veterans Administration-RO
St. Paul, MN
ATTN: Director

Veterans Administration-RO
Jackson, MS
ATTN: Director

Veterans Administration-RO
Huntington, WV
ATTN: Director

Veterans Administration-RO
St. Louis, MO
ATTN: Director

Veterans Administration-RO
Ft. Harrison, MT
ATTN: Director

OTHER GOVERNMENT AGENCIES (Continued)

Veterans Administration-RO
Lincoln, NE
ATTN: Director

Veterans Administration-RO
Reno, NV
ATTN: Director

Veterans Administration-RO
Manchester, NH
ATTN: Director

Veterans Administration-RO
Newark, NJ
ATTN: Director

Veterans Administration-RO
Milwaukee, WI
ATTN: Director

Veterans Administration-RO
Albuquerque, NM
ATTN: Director

Veterans Administration-RO
Buffalo, NY
ATTN: Director

Veterans Administration-RO
New York, NY
ATTN: Director

Veterans Administration-RO
Winston-Salem, NC
ATTN: Director

Veterans Administration-RO
Fargo, ND
ATTN: Director

Veterans Administration-RO
Cleveland, OH
ATTN: Director

Veterans Administration-RO
Muskogee, OK
ATTN: Director

Veterans Administration-RO
Portland, OR
ATTN: Director

Veterans Administration-RO
Pittsburgh, PA
ATTN: Director

Veterans Administration-RO
Philadelphia, PA
ATTN: Director

Veterans Administration-RO
San Francisco, CA
ATTN: Director

Veterans Administration-RO
San Juan, Puerto Rico
ATTN: Director

OTHER GOVERNMENT AGENCIES (Continued)

Veterans Administration-RO
Columbia, SC
ATTN: Director

Veterans Administration-RO
Sioux Falls, SD
ATTN: Director

Veterans Administration-RO
Houston, TX
ATTN: Director

Veterans Administration-RO
Waco, TX
ATTN: Director

Veterans Administration-RO
Salt Lake City, UT
ATTN: Director

Veterans Administraiton-RO
White River Junction, VT
ATTN: Director

Veterans Administration-RO
Roanoke, VA
ATTN: Director

Veterans Administration-RO
Cheyenne, WY
ATTN: Director

Veterans Administration-RO
San Diego, CA
ATTN: Director

Veterans Administration-RO
Boise, ID
ATTN: Director

Veterans Administration-RO
Detroit, MI
ATTN: Director

Veterans Administration-RO
Nashville, TN
ATTN: Director

The White House
ATTN: Domestic Policy Staff

DEPARTMENT OF ENERGY CONTRACTORS

Lawrence Livermore National Lab
ATTN: Tech Info Dept Library

Los Alamos National Scientific Lab
ATTN: Library
ATTN: MS 195

Sandia National Lab
ATTN: W. Hereford
ATTN: Central Library

Reynolds Electrical & Engr Co., Inc
ATTN: CIC
ATTN: W. Brady

DEPARTMENT OF DEFENSE CONTRACTORS

Adams State College
ATTN: Librn

Advanced Research & Applications Corp
ATTN: H. Lee

Akron Public Library
ATTN: Librn

Alabama State Dept of Archives & History
ATTN: Military Records Div

University of Alabama
ATTN: Reference Dept, Dralier 3
ATTN: Director of Libraries (Reg)

University of Alaska Library at Anchorage
ATTN: Dir of Libraries

University of Alaska
ATTN: Librn

Albany Public Library
ATTN: Librn

Alexander City State Jr College
ATTN: Librn

Allegheny College
ATTN: Librn

Allen County Public Library
ATTN: Librn

Altoona Area Public Library
ATTN: Librn

American Statistics Index
Congressional Info Service, Inc
ATTN: Cathy Jarvey

Anaheim Public Library
ATTN: Librn

College of Wooster
ATTN: Gov Docs

Angelo State University Library
ATTN: Librn

Angelo Icoboni Public Library
ATTN: Librn

Anoka County Library
ATTN: Librn

Appalachian State University
ATTN: Library Docs

Arizona State University Library
ATTN: Librn

University of Arizona
ATTN: Dir of Libraries (Reg)

Arkansas College Library
ATTN: Library

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Arkansas Library Comm
ATTN: Library

Arkansas State University
ATTN: Library

University of Arkansas
ATTN: Gov Docs Div

Austin College
ATTN: Librn

Atlanta Public Library
ATTN: Ivan Allen Dept

Atlanta University
ATTN: Librn

Auburn University Library at Mongomery (Reg)
ATTN: Librn

C. W. Post Ctr Long Island University
ATTN: Librn

Bangor Public Library
ATTN: Librn

Bates College Library
ATTN: Librn

Baylor University Library
ATTN: Docs Dept

Beloit College Libraries
ATTN: Serials Docs Dept

Bemidji State College
ATTN: Library

State University College
ATTN: Gov Docs

Akron University
ATTN: Gov Docs

Boston Public Library (Reg)
ATTN: Docs Dept

Bowdoin College
ATTN: Librn

Bowling Green State University
ATTN: Lib Gov Docs Services

Bradley University
ATTN: Librn

Brandeis University Library
ATTN: Docs Section

Brigham Young University
ATTN: Docs Collection

Brookhaven National Laboratory
ATTN: Tech Library

Brooklyn College
ATTN: Doc Div

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Broward County Library Sys
ATTN: Librn

Brown University
ATTN: Librn

Bucknell University
ATTN: Reference Dept

Buffalo & Erie Co Public Library
ATTN: Librn

State University Library of California at Fresno
ATTN: Library

University Library of California at Los Angeles
ATTN: Pub Affairs Serv U.S. Docs

University of California at San Diego
ATTN: Docs Dept

State College Library of California at Stanislaus
ATTN: Library

California State Polytechnic University Library
ATTN: Librn

California State University at Northridge
ATTN: Gov Doc

California State Library (Reg)
ATTN: Librn

California State University at Long Beach Library
ATTN: Librn

California State University
ATTN: Librn

California State University
ATTN: Librn

California University Library
ATTN: Gov Pub Dept

California University Library
ATTN: Librn

California University Library
ATTN: Gov Docs Dept

California University Library
ATTN: Docs Sec

University of California
ATTN: Gov Docs Dept

Calvin College Library
ATTN: Librn

Kearney State College
ATTN: Gov Docs Dept

Cambria County Library Sys
ATTN: Librn

Carleton College Library
ATTN: Librn

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Carnegie Library of Pittsburgh
ATTN: Librn

Carnegie Mellon University
ATTN: Dir of Libraries

Carson Regional Library
ATTN: Gov Pubs Unit

Case Western Reserve University
ATTN: Librn

Casper College
ATTN: Librn

University of Central Florida
ATTN: Library Docs Dept

Central Michigan University
ATTN: Library Docs Sec

Central Montana State College
ATTN: Gov Docs

Central State University
ATTN: Lib Docs Dept

Central Washington University
ATTN: Lib Docs Sec

Central Wyoming College Library
ATTN: Librn

Charleston County Library
ATTN: Librn

Charlotte & Mechlenburg County Public Library
ATTN: E. Correll

Chattanooga Hamilton County, Bicentennial Library
ATTN: Librn

Chesapeake Public Library System
ATTN: Librn

Chicago Public Library
ATTN: Gov Pubs Dept

State University of Chicago
ATTN: Librn

Chicago University Library
ATTN: Dir of Libraries
ATTN: Docs Processing

Cincinnati University Library
ATTN: Librn

Citadel, Daniel Library
ATTN: Librn

Claremont Colleges Libraries
ATTN: Doc Collection

Clemson University
ATTN: Dir of Libraries

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Cleveland Public Library
ATTN: Docs Collection

Cleveland State University Library
ATTN: Librn

Coe Library
ATTN: Docs Div

Colgate University Library
ATTN: Ref Lib

Colorado State University Libraries
ATTN: Librn

University of Colorado Libraries
ATTN: Dir of Libraries

Columbia University Library
ATTN: Docs Svc Ctr

Columbus & Franklin Cty Public Library
ATTN: Gen Rec Div

Compton Library
ATTN: Librn

Connecticut State Library (Reg)
ATTN: Librn

University of Connecticut
ATTN: Gov't of Connecticut

University of Connecticut
ATTN: Dir of Libraries

Cornell University Library
ATTN: Librn

Corpus Christi State University Library
ATTN: Librn

Culver City Library
ATTN: Librn

Curry College Library
ATTN: Librn

University of North Carolina at Asheville
ATTN: Librn

Dallas County Public Library
ATTN: Librn

Dallas Public Library
ATTN: Librn

Dalton Junior College Library
ATTN: Librn

Dartmouth College
ATTN: Librn

Davenport Public Library
ATTN: Librn

Davidson College
ATTN: Librn

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Dayton & Montgomery City Public Library
ATTN: Librn

University of Dayton
ATTN: Librn

Decatur Public Library
ATTN: Librn

Dekalb Community College SO CPUS
ATTN: Librn

Delaware Pauw University
ATTN: Librn

University of Delaware
ATTN: Librn

University of Delaware
ATTN: Dir of Libraries

Delta College Library
ATTN: Librn

Delta State University
ATTN: Librn

Denison University Library
ATTN: Librn

Denver Public Library (Reg)
ATTN: Docs Div

Dept of Library & Archives (Reg)
ATTN: Librn

Detroit Public Library
ATTN: Librn

Dickinson College Library
ATTN: Librn

Dickinson State College
ATTN: Librn

Alabama Agricultural Mechanical University & Coll
ATTN: Librn

Drake University
ATTN: Cowles Library

Drew University
ATTN: Librn

Duke University
ATTN: Pub Docs Dept

Duluth Public Library
ATTN: Docs Sec

East Carolina University
ATTN: Lib Docs Dept

East Central University
ATTN: Librn

East Islip Public Library
ATTN: Librn

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

East Orange Public Library
ATTN: U.S. Gov't Depository

East Tennessee State University Sherrod Library
ATTN: Docs Dept

East Texas State University
ATTN: Library

Monmouth County Library Eastern Branch
ATTN: Librn

Eastern Illinois University
ATTN: Librn

Eastern Kentucky University
ATTN: Librn

Eastern Michigan University Library
ATTN: Library

Eastern Montana College
ATTN: Lib Docs

Eastern Montana College Library
ATTN: Docs Dept

Eastern New Mexico University
ATTN: Librn

Eastern Oregon College Library
ATTN: Librn

Eastern Washington University
ATTN: Librn

El Paso Public Library
ATTN: Docs & Genealogy Dept

Elko County Library
ATTN: Librn

Elmire College
ATTN: Librn

Elon College Library
ATTN: Librn

Enoch Pratt Free Library
ATTN: Docs Ofc

Enory University
ATTN: Librn

Evansville & Vanderburgh Cty Public Library
ATTN: Librn

Everett Public Library
ATTN: Librn

Fairleigh Dickinson University
ATTN: Depository Dept

Florida A & M University
ATTN: Librn

Florida Atlantic University Library
ATTN: Div of Pub Docs

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Florida Institute of Technology
ATTN: Library

Florida International University Library
ATTN: Docs Sec

Florida State Library
ATTN: Docs Sec

Florida State University
ATTN: Librn

University of Florida
ATTN: Dir of Library (Reg)
ATTN: Docs Dept

Fond Du Lac Public Library
ATTN: Librn

Ft Hays State University
Ft Hays Kansas State College
ATTN: Librn

Ft Worth Public Library
ATTN: Librn

Free Public Library of Elizabeth
ATTN: Librn

Free Public Library
ATTN: Librn

Freeport Public Library
ATTN: Librn

Fresno Cty Free Library
ATTN: Librn

Gadsden Public Library
ATTN: Librn

Garden Public Library
ATTN: Librn

Gardner Webb College
ATTN: Docs Library

Gary Public Library
ATTN: Librn

Geauga Cty Public Library
ATTN: Librn

Georgetown University Library
ATTN: Gov Docs Room

Georgia Institute of Technology
ATTN: Librn

Georgia Southern College
ATTN: Librn

Georgia Southwestern College
ATTN: Dir of Libraries

Georgia State University Library
ATTN: Librn

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

University of Georgia
ATTN: Dir of Libraries (Reg)

Glassboro State College
ATTN: Librn

Gleeson Library
ATTN: Librn

Graceland College
ATTN: Librn

Grand Forks Public City-County Library
ATTN: Librn

Grand Rapids Public Library
ATTN: Dir of Lib

Greenville County Library
ATTN: Librn

Grinnell College Library
ATTN: Librn

Guam RFK Memorial University Library
ATTN: Fed Depository Coll

University of Guam
ATTN: Librn

Gustavus Adolphus College
ATTN: Librn

South Dakota University
ATTN: Librn

Hardin-Simmons University Library
ATTN: Librn

Hartford Public Library
ATTN: Librn

Harvard College Library
ATTN: Dir of Lib

Harvard College Library
ATTN: Serials Rec Div

University of Hawaii Library
ATTN: Gov Docs Coll

Hawaii State Library
ATTN: Fed Docs Unit

University of Hawaii at Monoa
ATTN: Dif of Libraries (Reg)

University of Hawaii
Hilo Campus Library
ATTN: Librn

Haydon Burns Library
ATTN: Librn

Hennepin County Library
ATTN: Gov Docs

Henry Ford Community College Library
ATTN: Librn

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Herbert H. Lehman College
ATTN: Lib Docs Div

Hofstra University Library
ATTN: Docs Dept

Hollins College
ATTN: Librn

Hopkinsville Community College
ATTN: Librn

Wagner College
ATTN: Librn

University of Houston Library
ATTN: Docs Div

Houston Public Library
ATTN: Librn

Tulane University
ATTN: Docs Dept

Hoyt Public Library
ATTN: Librn

Humboldt State College Library
ATTN: Docs Dept

Huntington Park Library
ATTN: Librn

Hutchinson Public Library
ATTN: Librn

Idaho Public Library & Information Center
ATTN: Librn

Idaho State Library
ATTN: Librn

Idaho State University Library
ATTN: Docs Dept

University of Idaho
ATTN: Dir of Libraries (Reg)
ATTN: Docs Sec

University of Illinois Library
ATTN: Docs Sec

Illinois State Library (Reg)
ATTN: Gov Docs Br

Illinois University at Urbana-Champaign
ATTN: P. Watson Docs Lib

Illinois Valley Community College
ATTN: Library

Illinois State University
ATTN: Librn

Indiana State Library (Reg)
ATTN: Serial Sec

Indiana State University
ATTN: Docs Library

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Indiana University Library
ATTN: Docs Dept

Indianapolis Marion County Public Library
ATTN: Social Science Div

Iowa State University Library
ATTN: Gov Docs Dept

Iowa University Library
ATTN: Gov Docs Dept

Butler University
ATTN: Librn

Isaac Delchdo College
ATTN: Librn

James Madison University
ATTN: Librn

JAYCOR
10 cy ATTN: Health & Environment Div

Jefferson County Public Library
Lakewood Regional Library
ATTN: Librn

Jersey City State College
ATTN: F. A. Irwin Library Periodicals
Doc Sec

John Hopkins University
ATTN: Docs Library

La Roche College
ATTN: Librn

Johnson Free Public Library
ATTN: Librn

JRB Associates
4 cy ATTN: L. Novotney

Kalamazoo Public Library
ATTN: Librn

Kaman Tempo
ATTN: DASIAC
ATTN: E. Martin

Kaman Tempo
ATTN: R. Miller

Kaman Tempo
ATTN: C. Jones

Kansas City Public Library
ATTN: Docs Div

Kansas State Library
ATTN: Librn

Kansas State University Library
ATTN: Docs Dept

University of Kansas
ATTN: Dir of Library (Reg)

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Kent State University Library
ATTN: Docs Div

Kentucky Dept of Library & Archives
ATTN: Docs Sec

University of Kentucky
ATTN: Gov Pub Dept
ATTN: Dir of Lib (Reg)

Kenyon College Library
ATTN: Librn

Lake Forest College
ATTN: Librn

Lake Sumter Community College Library
ATTN: Librn

Lakeland Public Library
ATTN: Librn

Lancaster Regional Library
ATTN: Librn

Lawrence University
ATTN: Docs Dept

Brigham Young University
ATTN: Docs & Map Sec

Lewis University Library
ATTN: Librn

Library and Statutory Dist & Svc
2 cy ATTN: Librn

Earlham College
ATTN: Librn

Little Rock Public Library
ATTN: Librn

Long Beach Public Library
ATTN: Librn

Los Angeles Public Library
ATTN: Serials Div U.S. Docs

Louisiana State University
ATTN: Gov Doc Dept
ATTN: Dir of Libraries (Reg)

Louisville Free Public Library
ATTN: Librn

Louisville University Library
ATTN: Librn

University of Texas
ATTN: Lyndon B. Johnson School of Public
Affairs Library

Maine Maritime Academy
ATTN: Librn

University of Maine
ATTN: Librn

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Manchester City Library
ATTN: Librn

Mankato State College
ATTN: Gov Pubs

University of Maine at Farmington
ATTN: Dir of Libraries

Marathon County Public Library
ATTN: Librn

Principia College
ATTN: Librn

University of Maryland
ATTN: McKeldin Library Docs Div

University of Maryland
ATTN: Librn

University of Massachusetts
ATTN: Gov Docs Coll

Maui Public Library
Kahuley Branch
ATTN: Librn

McNeese State University
ATTN: Librn

Memphis & Shelby County Public Library & Information Center
ATTN: Librn

Memphis & Shelby County Public Library & Information Center
ATTN: Librn

Memphis State University
ATTN: Librn

Mercer University
ATTN: Librn

Mesa County Public Library
ATTN: Librn

Miami Dade Community College
ATTN: Librn

University of Miami Library
ATTN: Gov Pubs

Miami Public Library
ATTN: Docs Div

Miami University Library
ATTN: Docs Dept

University of Santa Clara
ATTN: Docs Div

Michigan State Library
ATTN: Librn

Michigan State University Library
ATTN: Librn

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Michigan Tech University
ATTN: Lib Docs Dept

University of Michigan
ATTN: Acq Sec Docs Unit

Middlebury College Library
ATTN: Librn

Millersville State College
ATTN: Librn

State University of New York
ATTN: Docs Librn

Milwaukee Public Library
ATTN: Librn

Minneapolis Public Library
ATTN: Librn

University of Minnesota
ATTN: Dir of Libraries (Reg)

Minot State College
ATTN: Librn

Mississippi State University
ATTN: Librn

University of Mississippi
ATTN: Dir of Libraries

Missouri University at Kansas City General
ATTN: Librn

University of Missouri Library
ATTN: Gov Docs

M.I.T. Libraries
ATTN: Librn

Mobile Public Library
ATTN: Gov Info Div

Midwestern University
ATTN: Librn

Montana State Library
ATTN: Librn

Montana State University Library
ATTN: Librn

University of Montana
ATTN: Dir of Libraries (Reg)

Montebello Library
ATTN: Librn

Morhead State College
ATTN: Library

Mt Prospect Public Library
ATTN: Gov't Info Ctr

Murray State University Library
ATTN: Lib

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Nassau Library System
ATTN: Librn

National Academy of Sciences
ATTN: C. Robinette
ATTN: Medical Follow-Up Agency
ATTN: Natl Materials Advisory Board

Natrona County Public Library
ATTN: Librn

Nebraska Library Community
Nebraska Public Clearinghouse
ATTN: Librn

University of Nebraska at Omaha
ATTN: Univ Lib Docs

Nebraska Western College Library
ATTN: Librn

University of Nebraska
ATTN: Dir of Libraries (Reg)

University of Nebraska Library
ATTN: Acquisitions Dept

University of Nevada Library
ATTN: Gov Pubs Dept

University of Nevada at Las Vegas
ATTN: Dir of Libraries

New Hampshire University Library
ATTN: Librn

New Hanover County Public Library
ATTN: Librn

New Mexico State Library
ATTN: Librn

New Mexico State University
ATTN: Lib Docs Div

University of New Mexico
ATTN: Dir of Libraries (Reg)

University of New Orleans Library
ATTN: Gov Docs Div

New Orleans Public Library
ATTN: Librn

New York Public Library
ATTN: Librn

New York State Library
ATTN: Docs Control Cultural Ed Ctr

State University of New York at Stony Brook
ATTN: Main Lib Docs Sec

State University of New York City Memorial Library at Cortland
ATTN: Librn

State University of New York
ATTN: Lib Docs Sec

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

State University of New York
ATTN: Librn

New York State University
ATTN: Docs Ctr

State University of New York
ATTN: Docs Dept

New York University Library
ATTN: Docs Dept

Newark Free Library
ATTN: Librn

Newark Public Library
ATTN: Librn

Niagara Falls Public Library
ATTN: Librn

Nicholls State University Library
ATTN: Docs Div

Nieves M. Flores Memorial Library
ATTN: Librn

Norfolk Public Library
ATTN: R. Parker

North Carolina Agricultural & Tech State University
ATTN: Librn

University of North Carolina at Charlotte
ATTN: Atkins Lib Doc Dept

University Library of North Carolina at Greensboro
ATTN: Librn

University of North Carolina at Wilmington
ATTN: Librn

North Carolina Central University
ATTN: Librn

North Carolina State University
ATTN: Librn

University of North Carolina at Wilmington
ATTN: Librn

University of North Carolina
ATTN: BA SS Div Docs

North Dakota State University Library
ATTN: Docs Librn

University of North Dakota
ATTN: Librn

University of North Dakota
ATTN: Dir of Libraries

North Georgia College
ATTN: Librn

North Texas State University Library
ATTN: Librn

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Northeast Missouri State Univeristy
ATTN: Librn

Northeastern Oklahoma State University
ATTN: Librn

Northeastern University
ATTN: Dodge Library

Northern Arizona University Library
ATTN: Gov Docs Dept

Northern Illinois University
ATTN: Librn

Northern Michigan University
ATTN: Docs

Northern Montana College Library
ATTN: Librn

Northwestern Michigan College
ATTN: Librn

Northwestern State University
ATTN: Librn

Northwestern State University Library
ATTN: Librn

Northwestern University Library
ATTN: Gov Pubs Dept

Norwalk Public Library
ATTN: Librn

Northeastern Illinois University
ATTN: Library

University of Notre Dame
ATTN: Doc Ctr

Oakland Community College
ATTN: Librn

Oakland Public Library
ATTN: Librn

Oberlin College Library
ATTN: Librn

Ocean County College
ATTN: Librn

Ohio State Library
ATTN: Librn

Ohio State University
ATTN: Lib Docs Div

Ohio University Library
ATTN: Docs Dept

Oklahoma City University Library
ATTN: Librn

Oklahoma City University Library
ATTN: Librn

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Oklahoma Department of Libraries
ATTN: U.S. Gov Docs

University of Oklahoma
ATTN: Docs Div

Old Dominion University
ATTN: Doc Dept Univ Lib

Olivet College Library
ATTN: Librn

Omaha Public Library Clark Branch
ATTN: Librn

Onondaga County Public Library
ATTN: Gov Docs Sec

Oregon State Library
ATTN: Librn

University of Oregon
ATTN: Docs Sec

Ouachita Baptist University
ATTN: Librn

Pacific-Sierra Research Corp
ATTN: H. Brode

Pan American University Library
ATTN: Librn

Passaic Public Library
ATTN: Librn

Queens College
ATTN: Docs Dept

Pennsylvania State Library
ATTN: Gov Pubs Sec

Pennsylvania State University
ATTN: Lib Doc Sec

University of Pennsylvania
ATTN: Dir of Libraries

University of Denver
ATTN: Penrose Library

Peoria Public Library
ATTN: Business, Science & Tech Dept

Free Library of Philadelphia
ATTN: Gov Pubs Dept

Philipsburg Free Public Library
ATTN: Library

Phoenix Public Library
ATTN: Librn

University of Pittsburgh
ATTN: Docs Office, G8

Plainfield Public Library
ATTN: Librn

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Popular Creek Public Library District
ATTN: Librn

Association of Portland Library
ATTN: Librn

Portland Public Library
ATTN: Librn

Portland State University Library
ATTN: Librn

Pratt Institute Library
ATTN: Librn

Louisiana Tech University
ATTN: Librn

Princeton University Library
ATTN: Docs Div

Providence College
ATTN: Librn

Providence Public Library
ATTN: Librn

Public Library Cincinnati & Hamilton County
ATTN: Librn

Public Library of Nashville and Davidson County
ATTN: Librn

University of Puerto Rico
ATTN: Doc & Maps Room

Purdue University Library
ATTN: Librn

Quinebaug Valley Community College
ATTN: Librn

Auburn University
ATTN: Microforms & Docs Dept

Rapid City Public Library
ATTN: Librn

Reading Public Library
ATTN: Librn

Reed College Library
ATTN: Librn

Augusta College
ATTN: Librn

University of Rhode Island Library
ATTN: Gov Pubs Ofc

University of Rhode Island
ATTN: Dir of Libraries

Rice University
ATTN: Dir of Libraries

Louisiana College
ATTN: Librn

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Richland County Public Library
ATTN: Librn

Riverside Public Library
ATTN: Librn

University of Rochester Library
ATTN: Docs Sec

University of Rutgers Camden Library
ATTN: Librn

State University of Rutgers
ATTN: Librn

Rutgers University
ATTN: Dir of Libraries (Reg)

Rutgers University Law Library
ATTN: Fed Docs Dept

Salem College Library
ATTN: Librn

Samford University
ATTN: Librn

San Antonio Public Library
ATTN: Bus Science & Tech Dept

San Diego County Library
ATTN: C. Jones, Acquisitions

San Diego Public Library
ATTN: Librn

San Diego State University Library
ATTN: Gov Pubs Dept

San Francisco Public Library
ATTN: Gov Docs Dept

San Francisco State College
ATTN: Gov Pubs Coll

San Jose State College Library
ATTN: Docs Dept

San Luis Obispo City-County Library
ATTN: Librn

Savannah Public & Effingham Liberty Regional Library
ATTN: Librn

Science Applications, Inc
ATTN: Tech Library

Scottsbluff Public Library
ATTN: Librn

Scranton Public Library
ATTN: Librn

Seattle Public Library
ATTN: Ref Docs Asst

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Selby Public Library
ATTN: Librn

Shawnee Library System
ATTN: Librn

Shreve Memorial Library
ATTN: Librn

Silas Bronson Public Library
ATTN: Librn

Sioux City Public Library
ATTN: Librn

Skidmore College
ATTN: Librn

Slippery Rock State College Library
ATTN: Librn

South Carolina State Library
ATTN: Librn

University of South Carolina
ATTN: Librn

University of South Carolina
ATTN: Gov Docs

South Dakota School of Mines & Technical Library
ATTN: Librn

South Dakota State Library
ATTN: Fed Docs Dept

University of South Dakota
ATTN: Docs Librn

South Florida University Library
ATTN: Librn

Southeast Missouri State University
ATTN: Librn

Southeastern Massachusetts University Library
ATTN: Docs Sec

University of Southern Alabama
ATTN: Librn

Southern California University Library
ATTN: Docs Dept

Southern Connecticut State College
ATTN: Library

Southern Illinois University
ATTN: Librn

Southern Illinois University
ATTN: Docs Ctr

Southern Methodist University
ATTN: Librn

University of Southern Mississippi
ATTN: Library

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Southern Oregon College
ATTN: Library

Southern University in New Orleans Library
ATTN: Librn

Southern Utah State College Library
ATTN: Docs Dept

Southwest Missouri State College
ATTN: Library

University of Southwestern Louisiana Libraries
ATTN: Librn

Southwestern University
ATTN: Librn

Spokane Public Library
ATTN: Ref Dept

Springfield City Library
ATTN: Docs Sec

St Bonaventure University
ATTN: Librn

St Johns River Junior College
ATTN: Library

St Joseph Public Library
ATTN: Librn

St Lawrence University
ATTN: Librn

St Louis Public Library
ATTN: Librn

St Paul Public Library
ATTN: Librn

Stanford University Library
ATTN: Gov Docs Dept

State Historical Soc Library
ATTN: Docs Serials Sec

State Library of Massachusetts
ATTN: Librn

State University of New York
ATTN: Librn

Stetson University
ATTN: Librn

University of Steubenville
ATTN: Librn

Stockton & San Joaquin Public Library
ATTN: Librn

Stockton State College Library
ATTN: Librn

Albion College
ATTN: Gov Docs Librn

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Superior Public Library
ATTN: Librn

Swarthmore College Library
ATTN: Ref Dept

Syracuse University Library
ATTN: Docs Div

Tacoma Public Library
ATTN: Librn

Hillsborough County Public Library at Tampa
ATTN: Librn

Temple University
ATTN: Librn

Tennessee Technological University
ATTN: Librn

University of Tennessee
ATTN: Dir of Libraries

College of Idaho
ATTN: Librn

Texas A & M University Library
ATTN: Librn

University of Texas at Arlington
ATTN: Library Docs

University of Texas at San Antonio
ATTN: Library

Texas Christian University
ATTN: Librn

Texas State Library
ATTN: U.S. Docs Sec

Texas Tech University Library
ATTN: Gov Docs Dept

Texas University at Austin
ATTN: Docs Coll

University of Toledo Library
ATTN: Librn

Toledo Public Library
ATTN: Social Science Dept

Torrance Civic Center Library
ATTN: Librn

Traverse City Public Library
ATTN: Librn

Trenton Free Public Library
ATTN: Librn

Trinity College Library
ATTN: Librn

Trinity University Library
ATTN: Docs Coll

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Tufts University Library
ATTN: Docs Dept

University of Tulsa
ATTN: Librn

UCLA Research Library
ATTN: Pub Affairs Svc/U.S. Docs

Uniformed Services University of the Health Sciences
ATTN: LRC Library

University Libraries
ATTN: Dir of Lib

University of Maine at Oreno
ATTN: Librn

University of Northern Iowa
ATTN: Library

Upper Iowa College
ATTN: Docs Coll

Utah State University
ATTN: Librn

University of Utah
ATTN: Special Collections

University of Utah
ATTN: Dir of Library

Utica Public Library
ATTN: Librn

Valencia Library
ATTN: Librn

Valparaiso University
ATTN: Librn

Vanderbilt University Library
ATTN: Gov Docs Sec

University of Vermont
ATTN: Dir of Libraries

Virginia Commonwealth University
ATTN: Librn

Virginia Military Institute
ATTN: Librn

Virginia Polytechnic Institute Library
ATTN: Docs Dept

Virginia State Library
ATTN: Serials Sec

University of Virginia
ATTN: Pub Docs

Volusia County Public Library
ATTN: Librn

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Washington State Library
ATTN: Docs Sec

Washington State University
ATTN: Lib Docs Sec

Washington University Libraries
ATTN: Dir of Lib

University of Washington
ATTN: Docs Div

Wayne State University Library
ATTN: Librn

Wayne State University Law Library
ATTN: Docs Dept

Weber State College Library
ATTN: Librn

Wesleyan University
ATTN: Docs Librn

West Chester State College
ATTN: Docs Dept

West Covina Library
ATTN: Librn

Univeristy of West Florida
ATTN: Librn

West Georgia College
ATTN: Librn

West Hills Community College
ATTN: Library

West Texas State University
ATTN: Library

West Virginia College of Grad Studies Library
ATTN: Librn

University of West Virginia
ATTN: Dir of Libraries (Reg)

Westerly Public Library
ATTN: Librn

Western Carolina University
ATTN: Librn

Western Illinois University Library
ATTN: Librn

Western Washington University
ATTN: Librn

Western Wyoming Community College Library
ATTN: Librn

Westmoreland City Community College
ATTN: Learning Resource Ctr

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Whitman College
ATTN: Librn

Wichita State University Library
ATTN: Librn

Williams & Mary College
ATTN: Docs Dept

Emporia Kansas State College
ATTN: Gov Docs Div

William College Library
ATTN: Librn

Williamantic Public Library
ATTN: Librn

Winthrop College
ATTN: Docs Dept

University of Wisconsin at Whitewater
ATTN: Gov Docs Lib

University of Wisconsin at Milwaukee
ATTN: Lib Docs

University of Wisconsin at Oshkosh
ATTN: Librn

University of Wisconsin at Platteville
ATTN: Doc Unit Lib

University of Wisconsin at Stevens Point
ATTN: Docs Sec

University of Wisconsin
ATTN: Gov Pubs Dept

University of Wisconsin
ATTN: Acquisitions Dept

Worcester Public Library
ATTN: Librn

Wright State University Library
ATTN: Gov Docs Librn

Wyoming State Library
ATTN: Librn

University of Wyoming
ATTN: Docs Div

Yale University
ATTN: Dir of Libraries

Yeshiva University
ATTN: Librn

Yuma City County Library
ATTN: Librn


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